C 51.17/12:992/7

Tech Notes

July 1992

PB92-925907

PENNSYLVANIA STATE UNIVERSITY
AUG 24 1992
DOCUMENTS COLLECTION
U.S Depository Copy

Technology fact sheets from Federal laboratories

NTIS

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
Center for the Utilization of Federal Technology

U.S. DEPARTMENT OF COMMERCE
Barbara H. Franklin, Secretary of Commerce

National Technical Information Service
Donald R. Johnson, Acting Director

ISSN 0889-8464

COPYRIGHT WARNING
International Copyright © National Technical Information Service, 1992. All portions of this publication are protected against copying or other reproduction outside of the United States under the provisions of Article II of the Universal Copyright Convention. United States copyright is not asserted under the United States Copyright Law, Title 17, United States Code.

The Secretary of Commerce has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through 1992.

Tech Notes

Highlighting Selected U.S. Government Technology & Resources

July 1992

Contents

Agriculture & Food 474
Computers 476
Electrotechnology 480
Energy 489
Engineering 490
Environmental Science & Technology 505
Manufacturing, Machinery & Tools 506
Materials 516
Medicine & Biology 521
Physical Sciences 526
Transportation & Components 528

Published monthly by the National Technical Information Service (NTIS), Tech Notes bring together individual one- to two-page fact sheets prepared by Federal agencies, their laboratories, or contractors. These fact sheets highlight current Federal technology determined to have commercial or practical application. Topics cover new processes, materials, techniques, software, instrumentation, and resources.

Some of the current sources are the Department of the Navy, Department of the Army, NASA, Department of Energy, Environmental Protection Agency, Department of the Interior, and the Department of Agriculture.

Special assistance is provided by the Federal Laboratory Consortium.

Change of address or questions concerning subscriptions should be sent to:
Subscriptions Department
National Technical Information Service
Springfield, VA 22161
(703) 487-4630

Suggestions, comments, or questions concerning Tech Notes should be directed to:
Tech Notes Editor
Room 300B F
National Technical Information Service
Springfield, VA 22161
(703) 487-4805

How to Use Tech Notes

Every Tech Notes fact sheet lists a source for additional information. The source of this information may be a special support package from the originating agency, a personal contact, a licensing opportunity, or a backup report available from NTIS.

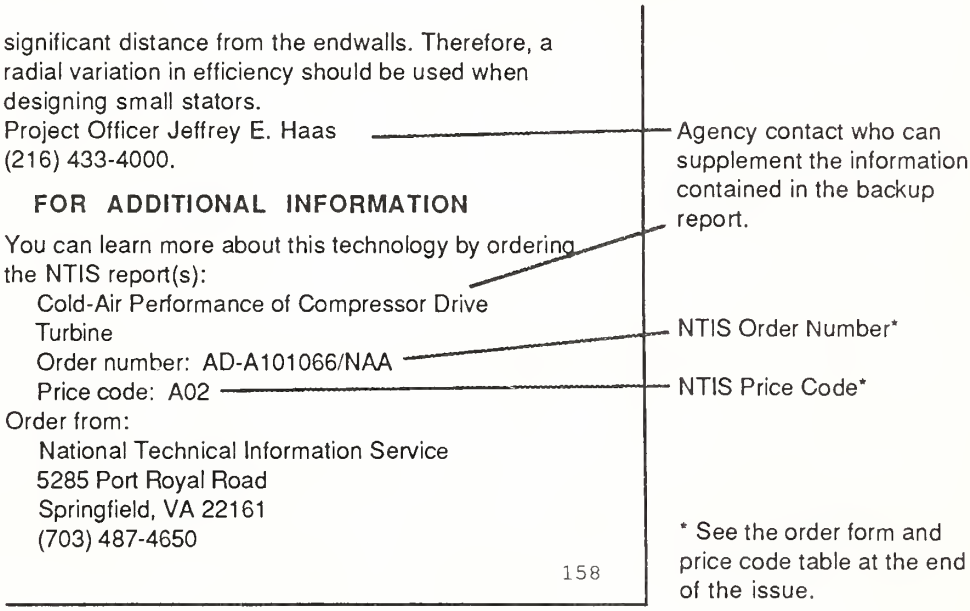
Each fact sheet also is perforated to allow for easy removal for those subscribers who may wish to keep a special fact sheet file or route to others in their organization

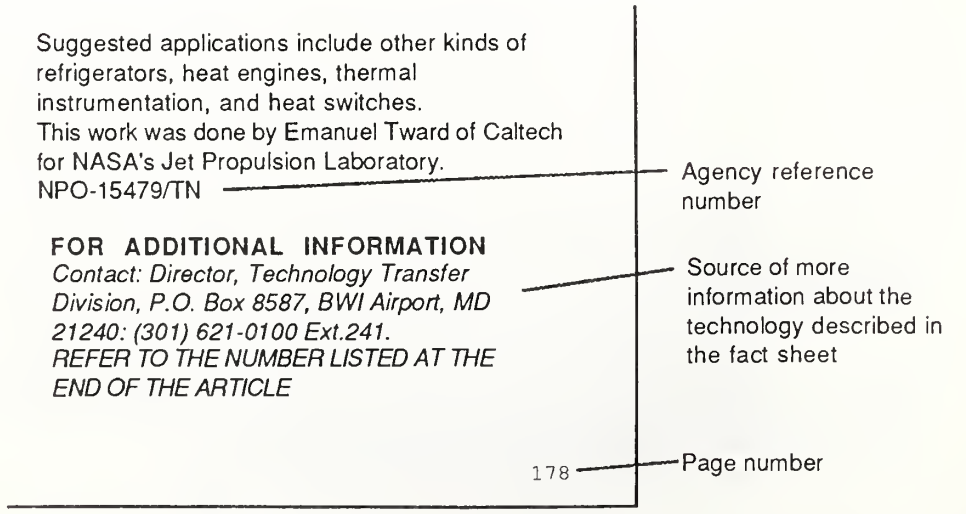
Sources of Further Backup Information

Below are two representative examples of how each Tech Note fact sheet provides you with a source of further information. In most cases, this information is provided directly by the agency or its laboratory.

However, there are cases where NTIS is the source for backup documentation. In these cases, use the order form at the end.

Examples:


significant distance from the endwalls. Therefore, a radial variation in efficiency should be used when designing small stators.
Project Officer Jeffrey E. Haas
(216) 433-4000.
FOR ADDITIONAL INFORMATION
You can learn more about this technology by ordering the NTIS report(s):
Cold-Air Performance of Compressor Drive Turbine
Order number: AD-A101066/NAA
Price code: A02
Order from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650
158
Agency contact who can supplement the information contained in the backup report.
NTIS Order Number*
NTIS Price Code*
* See the order form and price code table at the end of the issue.


Suggested applications include other kinds of refrigerators, heat engines, thermal instrumentation, and heat switches.
This work was done by Emanuel Tward of Caltech for NASA's Jet Propulsion Laboratory.
NPO-15479/TN
FOR ADDITIONAL INFORMATION
Contact: Director, Technology Transfer Division, P.O. Box 8587, BWI Airport, MD 21240: (301) 621-0100 Ext.241.
REFER TO THE NUMBER LISTED AT THE END OF THE ARTICLE
178
Agency reference number
Source of more information about the technology described in the fact sheet
Page number

Tech Notes Title List for July 1992

Agriculture & Food

0474 Enzyme Gets the Guava Juice Out

0475 Intensifying Tomato's Flavor

Computers

0476 Object Based Integrated Design (OBID)

0477 Electrostatic Particle-in-Cell Code for Hypercube Computer—A regular partition of the field grid serves well in a two-dimensional problem.

Software

0478 Program Aids Design of Fluid-Circulating Systems—CASE/A facilitates analysis of environmental-control and life-support systems of spacecraft.

0479 Program Helps To Optimize Assembly Sequences—FAST evaluates sequences for the assembly of the Space Station Freedom.

Electrotechnology

0480 Electrochromatic Optical Switching Device (Licensing Opportunity)

0481 SOI Fabrication

0482 Adaptive Vector-Quantization Scheme—Audio, video, or other signals are compressed efficiently.

0483 Automated Power-Distribution System—Capabilities include allocation and scheduling according to priorities, and also include recovery from faults

0484 Algorithms for Compression of Polarimetric-Radar Image Data—Data on background noise and effects of equipment are retained.

0485 Simulation of Static and Moving Acoustical Sources—Sounds in headphones are even changed according to movements of the listener's head.

0486 Single-Event-Upset Laser Scanner With Optical Bias—Additional steady illumination increases vulnerability to upset in the insensitive mode.

0487 Two AFC Loops for Low CNR and High Dynamics—Tracking abilities lie between those of a cross-product AFC loop and of a maximum-likelihood estimator.

Testing & Instrumentation

0488 Fiber-Optic Probe for Laser Velocimetry—The size and weight of optics would be reduced considerably. (Licensing Opportunity)

Other Items of Interest

0477 Electrostatic Particle-in-Cell Code for Hypercube Computer—A regular partition of the field grid serves well in a two-dimensional problem.

Energy

0489 Low-Temperature Hot Water Heat Distribution Systems

Other Items of Interest

0480 Electrochromatic Optical Switching Device (Licensing Opportunity)

Engineering

0490 Concurrent Engineering Handbook Available on Hypercard

0491 Unmanned Vehicle Available

0492 Acoustic Diagnostics Using a Remotely Operated Vehicle

0493 Pothole Patching

0494 Unsurfaced Road Management System

0495 Adjustably Preloaded Quick-Release Pin—An easy-to-use fastening device is adapted from a commercial product.

0496 Blast-Absorbing Bag—Stitches rip to dissipate explosive energy.

0497 Reflexive Avoidance of Obstacles by Robots—Sensor outputs are processed into synthetic force-field signals that are superimposed on control algorithms. (Licensing Opportunity)

0498 Fiber Jackets for Vibration-Damping Struts—Weak structural elements would be protected from overloads by braided fibers.

0499 Torque Tube Stiffens Trailer Frame—The tube isolates the cargo from twisting moments.

Software

0500 Composite-Blade Structural Analyzer—COBSTRAN computes stresses in blade-like structural components.

Testing & Instrumentation

0501 Instrument Measures Shift in Focus—Optical components can be tested at wavelengths from Ultraviolet to infrared.

0502 Low-Hysteresis Flow-Through Wind-Tunnel Balance—Symmetrical forces caused by internal flow are cancelled.

0503 Multiple-Axis Crosshairs—Three skewed lines provide alignment when viewed along each of three mutually orthogonal axes.

0504 Specimen Holder for Flammability Tests—A frame and clamps are designed to minimize local overstress on the specimen.

Environmental Science & Technology

0505 New Technique for Assessing Groundwater Quality

Manufacturing, Machinery & Tools

0506 Laser Drill Cell
0507 Cryogenic Cooling Improves Machine Tool Life
0508 Best Practices Library
0509 Methodologies For Product Integrity
0510 MSI Cell Emulation
0511 Technique Directly Deposits Copper Circuits onto Teflon

Testing & Instrumentation

0512 Increased Accuracy for CMM Probes
0513 Computer Program Aids Design of Impeller Blades—An iterative algorithm yields hydrodynamically optimal contours.
0514 Hybrid Hydrostatic/Transient Roller Bearing Assembly—The rolling-element bearing would be centrifugally unloaded at high speed. (Licensing Opportunity)
0515 Steel Collet for Welding Electrodes—A simple holder resists deformation and ensures reliable arc starting. (Licensing Opportunity)

Other Items of Interest

0490 Concurrent Engineering Handbook Available on Hypercard
0518 Metal Matrix Composite Vendor/Supplier Fabrication Evaluation

Materials

0516 Accelerated Cooled/Direct Quenched (AC/DQ) Steels
0517 Integrated Composites Center (ICC)
0518 Metal Matrix Composite Vendor/Supplier Fabrication Evaluation
0519 Mullite Whiskers and Mullite-Whisker Felt Produced
0520 Polymeric Electrolyte Containing 12-Crown-4 Ether—Ionic conductivity and charge-transfer efficiency are enhanced. (Licensing Opportunity)

Other Items of Interest

0511 Technique Directly Deposits Copper Circuits onto Teflon
0526 More Sensitive Analysis: X-Ray Microprobe/Microscope

Medicine & Biology

0521 From Cattle Toxin to Anti-Cancer Drug—Locoweed, poisonous to livestock, contains a component that destroys malignancies.
0522 Human Cell Repositories
0523 Containing Hair During Cutting in Zero Gravity—A device would enclose the head in a plastic bubble while a barber works.

Software

0524 Computer Graphics Simulation

Testing & Instrumentation

0525 White-Light, Dispersed-Fringe Interferometric Keratometer—A single 'snapshot' would suffice to map a cornea. (Licensing Opportunity)

Physical Sciences

0526 More Sensitive Analysis: X-Ray Microprobe/Microscope
0527 Measuring Magnetic Fields: The Mole

Other Items of Interest

0488 Fiber-Optic Probe for Laser Velocimetry—The size and weight of optics would be reduced considerably. (Licensing Opportunity)
0505 New Technique for Assessing Groundwater Quality
0520 Polymeric Electrolyte Containing 12-Crown-4 Ether—Ionic conductivity and charge-transfer efficiency are enhanced. (Licensing Opportunity)

Transportation & Components

0528 Automatic Pilot for Flight-Test Maneuvers—Experimental maneuvers can be repeated accurately.

Agriculture & Food

0474 Enzyme Gets the Guava Juice Out

0475 Intensifying Tomato's Flavor

Research Technology
Agricultural Research Service
U.S. Department of Agriculture

Enzyme Gets the Guava Juice Out

Juice from freshly picked guavas adds a light, clean taste to fruit beverages and carbonated drinks.

Food processors can extract a clear juice from guavas using natural enzymes, says ARS food technologist Harvey T. Chan at Hilo, Hawaii.

Chan and co-researchers reported recently that enzymes they've tested during the past few years yield more juice, in a shorter time, than those Chan tried more than a decade ago. What's more, today's guava juice is clearer and thinner, making it less likely to clog filters or narrow tubing used in producing sodas, sparkling water, and fruit juice blends. Blockages caused by bulky pulps, in contrast, can sometimes wreak havoc in bottling plants.

The thinner, clearer, amber-colored juice is also easier to make into a more highly concentrated product; that is, one that has very little water in it. "Because of the reduction in volume and weight," explains Chan, "it costs less to transport and store a concentrate than a full-strength juice. Later, at the bottling plant, you can add back as much water as you want."

Guava juice is high in vitamin C. It's also a good natural source of citric acid. That's an advantage for makers of all-natural beverages who need something besides synthetic citric acid to get the perfect balance of sweet and tart flavors in their product.

The hardworking enzymes Chan and colleagues used hasten the separation of juice from the thick pulp. The enzymes, called pectinases, speed the natural breakdown of pectin, a component of fruit cell walls.

In nature, fruits release their own pectinases as they ripen and soften. The scientists opted for pectinases derived from a fungus, *Aspergillus niger.*

Raised in indoor vats, *A. niger* is a prolific producer of the pectinases that are widely used to make wines or extract clear juice from apples, pears, pineapple, and about a dozen other fruits.

Chan worked with food technologists Aurora S. Hodgson and Catherine G. Cavaletto at the University of Hawaii and Conrad O. Perera at New Zealand's Department of Scientific and Industrial Research. They found that the enzymes work well on any kind of purée—fresh, thawed, or shelf-stable aseptic packs (the kind used for boxed juices).

Pectinases take about 2 hours to break down the pectins in guava purée that's heated to 122°F.

Although some of the nation's largest beverage companies have inquired about the clarified guava juice, they have yet to add it to their products, Chan says. But he and co-workers are still confident of the potential of today's clearer and thinner guava juice.

"When you list guava on a product label," Chan notes, "you're adding the appeal of both an exotic tropical fruit and an all-natural ingredient."

Harvey T. Chan, Jr., is with the USDA-ARS Tropical Fruit and Vegetable Research Laboratory, P.O. Box 4459, Hilo, HI 96720. Phone (808) 959-9138. ◆

Intensifying Tomato's Flavor

Your favorite spaghetti sauce or tomato soup might taste even better with a new seasoning cooked up by ARS researchers. The scientists developed the blend while researching ways to improve the flavor of fresh tomatoes. Their product, a patented blend of tomatoes' best natural flavors, enhances the rich taste of foods made from tomato paste or sauce.

It can also add the flavor of cooked tomatoes to foods like corn chips or hamburger that normally don't contain tomatoes.

In taste tests, flavor panelists said a high-quality spaghetti sauce and a popular tomato soup had an even better aroma when seasoned with the blend.

ARS research chemist Ronald G. Buttery and colleagues at the ARS Western Regional Research Center, Albany, California, produced the flavor mix. Surprisingly, none of the individual tomato compounds in their formula have the aroma or flavor of cooked tomatoes, he says. Instead, it's the combination of the natural chemicals, and the proportion of each, that create the pleasing fragrance and taste.

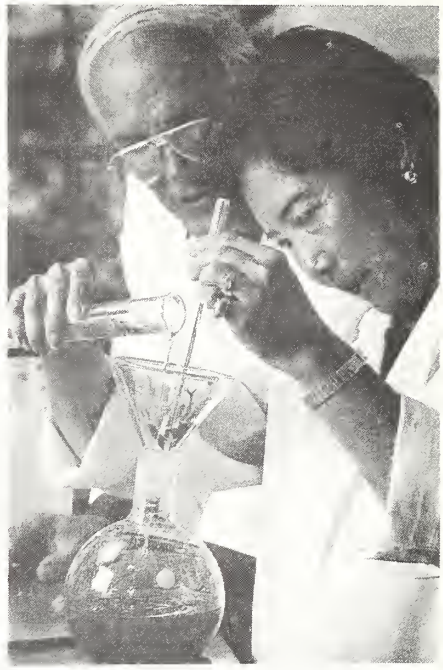
Buttery is an authority on tomato flavor. In experiments, he and co-researchers identified—from hundreds of flavor-imparting chemicals in tomatoes—those most important to tomato paste aroma.

They also calculated the natural ratio of each compound. These chemicals had the highest aroma ratings, that is, a score based on data from an instrument (gas chromatograph) and on the perceptions of sensory analysts who sniffed tomatoes' aromatic chemicals.

The researchers then chose seven of the highest ranking of these aroma compounds for the flavor blend. They used most of the chemicals in about the same proportion that they occur naturally in cooked tomatoes.

Most of the compounds are available from commercial sources, and all but one are already approved for food use.

JACK DYKINGA



Technician Louisa Ling prepares tomato paste sample for flavor analysis by chemist Ron Buttery at the Western Regional Research Center. (K-4507-1)

Buttery says the blend can be encapsulated in gelatin to sprinkle on foods and can also be mixed with salt, black pepper, garlic powder, dried herbs, or other familiar seasonings.

One drop, says Buttery, is "enough to boost the flavor of 20 one-quart jars of spaghetti sauce."

ARS.

For further information on Patent No. 5,064,673, "Cooked Tomato Flavor Composition," contact Ronald G. Buttery, USDA-ARS Western Regional Research Center, Cereal Product Utilization Research, 800 Buchanan St., Albany, CA 94710. Phone (510) 559-5667. ◆

Computers

0476 Object Based Integrated Design (OBID)

0477 Electrostatic Particle-in-Cell Code for Hypercube Computer—A regular partition of the field grid serves well in a two-dimensional problem.

Software

0478 Program Aids Design of Fluid-Circulating Systems—CASE/A facilitates analysis of environmental-control and life-support systems of spacecraft.

0479 Program Helps To Optimize Assembly Sequences—FAST evaluates sequences for the assembly of the Space Station Freedom.

Object Based Integrated Design (OBID)

The use of database and communication standards, like the structured query language and the open systems interconnection, have enabled designers and engineers to access a large variety of databases to support their activities. Because of the volume of information available, a method was needed that would coordinate the steps and applications used in the design process and organize the data needed to support those applications. The objective of this Phase II Small Business Innovation Research contract, which was completed by Universal Energy Systems (UES) in December, 1991, was to create an object-oriented design engineer assistant in a parallel processing and database management environment. The implementation and commercialization efforts for the Object Based Integrated Design program focused on two pilot sites: the Team Columbus/McDonnell Douglas Facility in Columbus, Ohio and the Allison Gas-Turbine Engine Plant in Indianapolis, Indiana.

The OBID program created a knowledge based shell for assisting a process expert in developing a model which would link the applications used in the design process to the proper data resources. This model included a facility to involve rules within the process model so decision criteria could be incorporated based on the results of the applications activated within the shell.

The OBID Knowledge Integration (KI) shell was used at Team Columbus to provide a means of automating the team design process. In the team organization, the typical hierarchy is flattened, and members from the requisite disciplines are assigned to teams that produce a certain product. The KI shell provided a means to develop a management strategy, which guided team members unfamiliar with the entire production process.

The Allison Engine Facility used Triad, a commercialization of the KI shell sold by IBM under a licensing agreement with UES. Using the KI shell to help sift through piles of aerodynamic and finite element analysis data, Allison developed a prototype blade design system which reduced design time from weeks to days. Additionally, because of the speed of the design iterations, designers now have sufficient time to optimize blade design rather than accepting the first feasible design because of time constraints.

The benefits of the KI shell are clear. It provides a process expert and the ability to guide the development of a product based on the correct invocation of design and analysis applications. The question of which application to run next and which data to access can be predetermined. This ability has been proven to cut design time of components, such as compressor blades, by 60 percent.

The OBID project has also demonstrated the ability to build knowledge shells which can guide the activities and functions of an organization as they were designed to be performed. The KI shell can duplicate the activities designed in functional and process models, similar to those provided by Integrated Computer Aided Manufacturing Definition Method tools. UES has continued to build a library of generic process models, which can be used as a starting point to design company-specific process models. This philosophy can provide companies important building blocks for iterating their particular processes.

FOR ADDITIONAL INFORMATION: To discuss this effort further, contact: Project Engineer: Brian Stucke, Air Force Manufacturing Technology Program, ATTN: AFWAL/WL/MTIA, Wright Patterson AFB, OH 45433-6533; (513)255-7371. Refer to contract: F33615-89-C-5709.

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

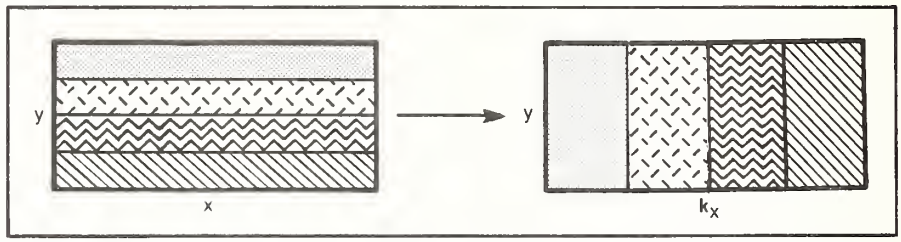
Electrostatic Particle-in-Cell Code for Hypercube Computer

A regular partition of the field grid serves well in a two-dimensional problem.

A code that simulates two-dimensional motions of plasma particles in a self-consistent electrostatic field and an externally applied magnetic field has been developed for execution on the Mark IIIfp hypercube computer. The code is of the particle-in-cell type, in which particles are deemed to move among the cells of the computational grid. This code is based on a generalization of a one-dimensional particle-in-cell algorithm that is applicable to many different parallel computing architectures. As such, it is an intermediate product of a continuing effort to speed particle-in-cell computations by taking advantage of distributed-memory parallel computers like those of the hypercube class.

A plasma particle-in-cell code propagates, in time, the trajectories of thousands to millions of charged particles. At each time step, two major computations are performed: first, the position and velocity of each particle are updated by integration of Newton's equations of motion in the electric and magnetic fields (this update is called the "particle push"), and the charges at their updated positions are interpolated onto the grid used to compute the fields. Next, the updated distribution of charges is used to update the electrostatic field. Because the particle push requires the majority of the computation time, it is necessary to assign an approximately equal number of particles to each of the processors to obtain the maximum advantage from parallel computing. The grid used to compute the fields must also be distributed among the processors, not necessarily in the same manner as that of the particle push.

In this specific two-dimensional case, the field grid is decomposed in a regular manner, assigning each part to a processor. This makes it necessary to transfer a particle from one processor to another when its updated position is found to be in the portion of the field grid handled by the other processor. In principle, this could give rise to large imbalances among the numbers of particles (and, therefore, the computational loads assigned to the processors). In practice, for the class of problems for which this regular decomposition is appropriate, large imbalances do not occur.



In this **Field-Grid Decomposition** for the two-dimensional fast Fourier transform (FFT), a strip of the field grid is assigned to each processor initially so that it can do one-dimensional FFT's in *x* for its subset of the *y* dimension. The results are then redistributed so that each processor is responsible for a strip oriented along *y*. One-dimensional FFT's in *y* can then be performed in each processor for its subset of $\mathbf{k}_x$.

The main loop of the computer code proceeds as follows. First, the distribution of charges in real space is interpolated onto the field grid, then transformed into **k** space by a two-dimensional fast Fourier transform (see figure) algorithm. Poisson's equation is solved in **k** space, and the *x* and *y* components of the electric field are computed from its solution. Then the two components of the electric field are transformed back into real space.

The interpolation of the fields from the grid for all of the particles requires guard rows on both sides of the grid, because particles at a grid boundary require field information from the processor responsible for the neighboring part of the grid. This guard-row information is exchanged between processor neighbors before the push phase begins. The processors are mapped into a logical ring so that only communication between nearest neighbors is required for the exchanges. Because some particle charge is interpolated onto the guard rows, these rows must be combined with their counterparts in adjacent processors before the deposition of charge is complete. This, too, requires only nearest-neighbor communication.

The code has been applied to a problem of 16,128 particles on a 32×128 field grid. The computational efficiency for the particle push was found to remain close to 100 percent as the number of processors was increased from 1 to 32. However, the computational efficiency for the solution of the field equations and, therefore, the overall computational efficiency decreased as the number of processors was increased. This decrease is attributed to an increase in communication among processors necessary to solve the field equations.

This work was done by Robert D. Ferraro and Paulett C. Liewer of Caltech for Viktor K. Decyk of UCLA for **NASA's Jet Propulsion Laboratory.**
NPO-18229/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Program Aids Design of Fluid-Circulating Systems

CASE/A facilitates analysis of environmental-control and life-support systems of spacecraft.

The design and analysis of environmental-control and life-support systems (ECLSS) and active thermal-control systems (ATCS) for spacecraft missions require powerful software that is flexible and responsive to the demands of particular projects. The Computer Aided Systems Engineering and Analysis (CASE/A) program is an interactive software tool for trade study and analysis, designed to increase productivity during all phases of systems engineering. The graphics-based command-driven software package provides a user-friendly computing environment in which the engineer can analyze the performance and interface characteristics of an ECLS/ATC system. The software package is useful during all phases of a spacecraft-design program, from initial conceptual design trade studies to the actual flight, including pre-flight prediction and in-flight analysis of anomalies.

The CASE/A computer program consists of three fundamental parts: (1) the schematic-management system, (2) the data-base-management system, and (3) the simulation-control-and-execution system. The schematic-management system enables the user to construct a model of a system graphically by arranging icons that represent components of the system and connecting the icons to represent the physical fluid streams. Version 4.1 contains 51 fully coded and documented default component routines. New components can be added by the user through the "blackbox" component option. The data-base-management system supports the storage and manipulation of data on components, outputs, and solution criteria through interactive editing screens. The simulation-control-and-execution system initiates and controls the iterative solution process, displaying time statuses and any necessary diagnostic messages.

In addition to these primary functions, the program provides functions in three other important areas: (1) management of the outputs of mathematical models, (2) system-utility commands, and (3) capacity for user operations logic. The model-output-management system provides the capability for tabular and graphical outputs. Complete data on the mass fractions and properties of fluid constituents (mass flow, pressure, temperature, specific heat, density, and viscosity) are generated at output intervals selected by the user and stored for reference. The Integrated Plot Utility (IPU) provides the capability of plotting all output data. System-utility commands are provided to enable the user to operate more efficiently in the CASE/A environment. The user is able to customize a simulation through optional operations FORTRAN logic. This code developed by the user is compiled and linked with a CASE/A mathematical model and enables the user to control the parameters of operation of components and assign those parameters to time lines during various phases of the iterative solution process.

CASE/A provides for transient tracking of the constituents of a flow stream and for determination of thermodynamic state of the constituents throughout an ECLSS/ATCS simulation, performing analyses of the transfer of heat, chemical reactions, mass and energy balances, and drops in pressure, on the basis of conditions of operation as specified by the user. The program tracks each constituent through all combination and decomposition states while maintaining a mass and energy balance on the overall system. This enables rapid assessment of designs of ECLSS; of the effects of alternate technologies; and of effects caused by changes in metabolic forcing functions, by the usage of consumables, and by system-control considerations.

CASE/A is written in FORTRAN 77 for the DEC VMX/VMS series of computers and requires 12 Mb of disk storage and a minimum paging file quota of 20,000 pages. The program operates on the Tektronix 4014 graphics standard and VT100 text standard. The program requires a Tektronix 4014 or later graphics terminal, a third party composite graphics/text terminal, or a personal computer loaded with appropriate VT100/TEK 4014 emulator software. The use of composite terminals or personal computers with popular emulation software is recommended for enhanced CASE/A operations and general ease of use. The program is available on an unlabeled 9-track, 6,250-bit/in. (15,875-bit/cm) magnetic tape in DEC VMS backup format. The development of CASE/A began in 1985 under contract to NASA/Marshall Space Flight Center. The latest version (4.1) was released in 1990.

Tektronix and TEK 4014 are trademarks of Tektronix, Inc. VT100 is a trademark of Digital Equipment Corp.

This program was developed by Allen Bacskay of **Marshall Space Flight Center** *and Robert Dalee of McDonnell Douglas Corp.* *MFS-28573/TN*

FOR ADDITIONAL INFORMATION

CONTACT

COSMIC®
112 Barrow Hall
University of Georgia
Athens, GA 30602

(404) 542-3265

Program Helps To Optimize Assembly Sequences

FAST evaluates sequences for the assembly of the Space Station *Freedom*.

FAST is a project-management software tool designed to optimize the sequence of assembly of the Space Station *Freedom*. An appropriate assembly sequence involves the coordination of requirements with respect to engineering, design, utilization, availability of transportation, and operations. Because complex designs tend to change frequently, FAST assesses effects of detailed changes upon the system and produces output metrics that identify preferred assembly sequences.

FAST incorporates Space-Shuttle integration, Space-Station hardware, on-orbit operations, and governing programmatic considerations as either precedence relations or numerical data. Hardware-sequencing information can either be put in directly and evaluated via the "specified" mode of operation or be evaluated from the input precedence relations in the "flexible" mode.

In the "specified" mode, FAST takes as its input a list of the cargo elements assigned to each flight. The program determines those positions of the cargo elements that maximize the margin on the center of gravity. These positions are restricted by the geometry of the cargo elements and the location of attachment fittings both in the Space Shuttle and on the cargo elements. FAST calculates every permutation of locations of cargo elements according to their heights, locations of trunnion fittings, and required distances between cargo elements. Each cargo element is tested in both its normal and reversed orientation (rotated 180°). The best solution is considered to be the one that maximizes the margin on the center of gravity for each flight.

In the "flexible" mode, FAST begins with the first flight and determines all feasible combinations of cargo elements according to mass, volume, extravehicular activity, and constraints imposed by precedence relations. The program generates an assembly sequence that meets mass, volume, position, extravehicular-activity, and precedence constraints while minimizing the total number of Shuttle flights required.

Issues associated with ground operations, performance of spacecraft, logistical requirements, and users' requirements will be addressed in future versions of FAST.

FAST is written in the C language and has been implemented on DEC VAX-series computers running VMS. The program is distributed in executable form. The source code is also provided, but it cannot be compiled without the Tree Manipulation Based Routines (TMBR) package from NASA's Jet Propulsion Laboratory, which will be available from COSMIC in the future. The main memory requirement is based on the data used tc drive the FAST program. All applications should be easily run on a computer that has 10 Mb of main memory. FAST was developed in 1990.

DEC, VAX, and VMS are trademarks of Digital Equipment Corp.

This program was written by Chester S. Borden, David G. Werntz, and Steven J. Loyola of Caltech for **NASA's Jet Propulsion Laboratory**.
NPO-18462/TN

FOR ADDITIONAL INFORMATION

CONTACT

COSMIC®
112 Barrow Hall
University of Georgia
Athens, GA 30602

(404) 542-3265

Electrotechnology

0480 Electrochromatic Optical Switching Device (Licensing Opportunity)

0481 SOI Fabrication

0482 Adaptive Vector-Quantization Scheme—Audio, video, or other signals are compressed efficiently.

0483 Automated Power-Distribution System—Capabilities include allocation and scheduling according to priorities, and also include recovery from faults

0484 Algorithms for Compression of Polarimetric-Radar Image Data—Data on background noise and effects of equipment are retained.

0485 Simulation of Static and Moving Acoustical Sources—Sounds in headphones are even changed according to movements of the listener's head.

0486 Single-Event-Upset Laser Scanner With Optical Bias—Additional steady illumination increases vulnerability to upset in the insensitive mode.

0487 Two AFC Loops for Low CNR and High Dynamics—Tracking abilities lie between those of a cross-product AFC loop and of a maximum-likelihood estimator.

Testing & Instrumentation

0488 Fiber-Optic Probe for Laser Velocimetry—The size and weight of optics would be reduced considerably. (Licensing Opportunity)

Other Items of Interest

0477 Electrostatic Particle-in-Cell Code for Hypercube Computer—A regular partition of the field grid serves well in a two-dimensional problem.

Department of Energy

Technology Application

Lawrence Berkeley Laboratory

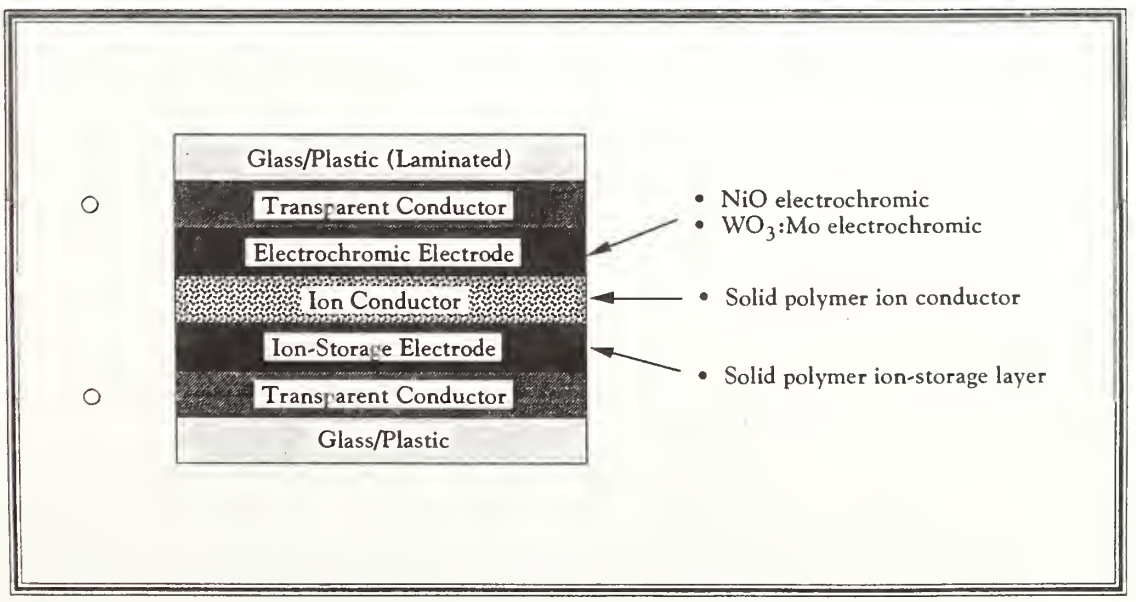
Electrochromatic Optical Switching Device

Researchers at Lawrence Berkeley Laboratory (LBL) have developed a ***highly versatile, cost-effective, easy-to-construct***, solid state, electrochromic optical switching device. LBL's device combines electrically conductive film, electrochromic film and a unique reversibly polymeric electrode to produce a product that can instantly switch the tint of a display, sunroof, mirror, or window from transparent to deeply colored. In addition to the usual uses of electrochromic films, the technology is ideal for use in energy efficient windows.

LBL's improved electrochromic structure permits the construction of an inexpensive device that uses only solid state materials that are chemically compatible, and can be used with hydrogen, lithium, sodium and other ionic transport elements. The use of a reversible organodisulfide polymer counter electrode, which is transparent in both the charged (polymeric) and uncharged (monomeric) states, simplifies matching up the characteristics of electrochromic electrodes (both cathodic and anodic types). The charge storage capacity of the organodisulfide electrode can be adjusted to meet the requirements of the particular electrochromic electrode used. This gives a product designer maximum flexibility in constructing switchable devices with the amount of light transmission desired.

Current Methods—Difficult and Costly

When constructing transparent electrochromic devices using current commercial methods, the counter electrode of the cell must either be a colorless electrode or contain matching electrochromic



IMPROVED ELECTROCHROMIC OPTICAL SWITCHING DEVICE

material which will also become transparent at the same charge/discharge level as the first electrode. Since one electrode functions as the cathode and the other as the anode, two different electrochromic materials must be utilized which will have the same matching or complimentary characteristics—not an easy task. The cost of the electrode materials used is also a factor which must be taken into account when producing electrochromic switching devices, as well as the chemical compatibility of the electrode materials to one another, and to other materials used in the cell such as electrolytes, separators, insulators, etc. The choice of electrode materials is further constricted by the need to choose electrode materials which will not form insoluble (nonreversible) compounds in the cell which would otherwise greatly shorten the life of the device, such as the number of charge/discharge cycles. It is also advantageous, from the standpoint of handling, as well as corrosion, to use solid state materials instead of liquid materials in the construction of an electrochromic device.

Technology Highlights

- All materials are solid state for longer life. Solid state construction also means they're easily scaled up.
- Uses an electrochromic material and a transparent, reversible organodisulfide polymer as electrodes that allow for a wide range of fabrication techniques.
- Adjustable charge storage capacity of organosulfide polymer electrode allows speed-up of switching operation.

This invention arose in the course of research supported by the Assistant Secretary for Conservation and Renewable Energy, Office of Building Technology, Building Systems and Materials Division, US Department of Energy.

Advantages

- Low absorption in the bleached states—transparent structure increases transmission
- Easy to process
- Low toxicity
- Low cost materials

Applications

- Switchable rear view mirrors and sun visors
- Optical shutters for light control in automobile, architectural, aircraft, marine windows, and spacecraft windows
- Window displays for watches, calculators
- Computer display screens, voltage sensors
- Eyeglasses, sunglasses, protective goggles

Potential Energy Savings for U.S.

25% of this country's building energy is lost through windows. Energy-efficient windows constructed of switchable electrochromic materials would result in substantial lighting, heating, and cooling energy savings during daylight hours in existing homes and buildings. Ideally, the window would be controlled by a dimmer switch which would darken the device to varying degrees. Or, the window could be wired to the building's heating and cooling system and react automatically to changing light conditions. Electrochromics alone could eliminate the need for 40 full-size power plants, mostly through reduced cooling requirements.

Development Status

- Optimize device
- Scale up prototype
- Test in environment
- **Patent pending**
- **Ready to license**

LBL is currently seeking companies interested in licensing the device and production technique for this unique technology.

For further information contact:
Mark Owens, Jr
Technology Transfer Office
Lawrence Berkeley Laboratory
1 Cyclotron Road
Mail Stop 90-1070
Berkeley, CA 94720
ph: (510) 486-6463
FAX: (510) 486-6457

U.S. Navy Fact Sheet

SOI Fabrication

The Naval Research Laboratory (NRL), Washington, DC, has developed a technique to fabricate silicon-on-insulator (SOI) materials. Using a strained 30-percent germanium (Ge) silicon germanium (SiGe) alloy as an etch stop, SOI wafers with a 200-nonometer silicon thickness have been fabricated using bond and etch batch techniques. The residual background doping was measured and found to be very small, at less than 10 to the -15 cc.

This material has the advantage of having a back channel that can be radiation hardened in a straightforward manner because the oxide forming the back channel is grown by conventional techniques. It also has the advantage over boron as an etch stop because germanium is not an electrically active dopant in silicon. The technology is capable of generating undoped silicon on insulator of any thickness.

These materials will play a key role in the fabrication of the next generation of higher speed/fully depleted devices based on silicon and is highly relevant to Navy satellite survivability.

FOR ADDITIONAL INFORMATION: For information call Richard Rein (202) 767-3744.

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Adaptive Vector-Quantization Scheme

Audio, video, or other signals are compressed efficiently.

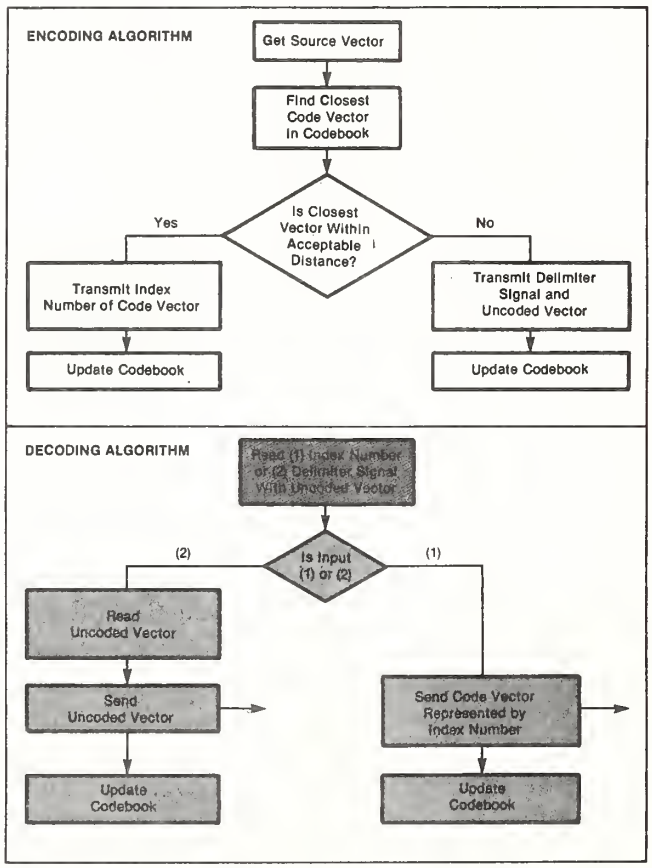
An adaptive vector-quantization scheme provides for the rapid encoding of signals for transmission in compressed form and for rapid decoding at the receiver. The scheme is versatile enough to be useful with a variety of signals; e.g., audio, video, and text.

Unlike some prior data-compression schemes, this one does not require advance knowledge of the statistics of the source signal and does not require the advance computation of a codebook. In this scheme, the codebook is generated "on the fly" and repeatedly adapted to capture the recent features of the source signal by use of a simple heuristic algorithm. The only arithmetic operations needed in this scheme are addition and subtraction, and the simplicity of the scheme lends itself to rapid implementation in both software and hardware. For these advantages, one pays a modest price in the form of a partial loss of data (distortion) during the encoding process.

The adaptive vector-quantization scheme (see figure) is based on a simple heuristic "move-to-front" protocol that effects lossless compression of high-rate textual data. For the purpose of this scheme, the protocol is modified to effect lossy compression of low-rate speech, image, or other analog data. The source data are grouped in chronological sequence into vectors. The encoder constructs a codebook in the form of an indexed list of data vectors (the code words) in order of decreasing statistical frequency. Both the encoder and the decoder maintain the same list, which is repeatedly updated with new source data in such a way that the more-recently-used code words are closer to the top of the list. Code words that have not been used for a long time are pushed toward the bottom of the list and eventually discarded.

A source vector is encoded by representing it with the index number of the code vector that approximates it most closely. The index numbers tend to be small rather than large. These index numbers can be further compressed using an entropy coder like a Huffman code, an arithmetic code, or an Elias code. Compression is thus achieved because fewer bits are needed to represent the index number than to transmit the quantized, source-vector data. The particular code vector, being the one most recently used, is moved to the top of the code list.

The **Adaptive Vector-Quantization Scheme** provides efficient coding for compression of signals. When applied to video, audio, or other analog signals, the sheme results in some loss of data, but this loss may be an acceptable price for economy and efficiency in many cases.



Occasionally, the distance between the source vector and any code word on the list exceeds a specified level that represents the maximum acceptable encoding distortion. In that case, the quantized source vector is transmitted uncoded, in its entirety, along with a "delimiter" signal that indicates that this is being done. This vector is then placed at the top of the code list, the other entries are moved down the list one slot, and the bottom entry on the list is discarded.

Because the same codebook is maintained in both the decoder and the encoder, decoding is straightforward. The decoder generates the decoded vectors from the received signal by using the received index numbers to refer to code vectors on the list, or by passing on the uncoded vector when it receives such a vector with its delimiter signal.

This work was done by Kar-Ming Cheung of Caltech for **NASA's Jet Propulsion Laboratory.**
NPO-18186/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and
Space Administration
Marshall Space Flight Center, Alabama

Automated Power-Distribution System

Capabilities include allocation and scheduling according to priorities, and also include recovery from faults.

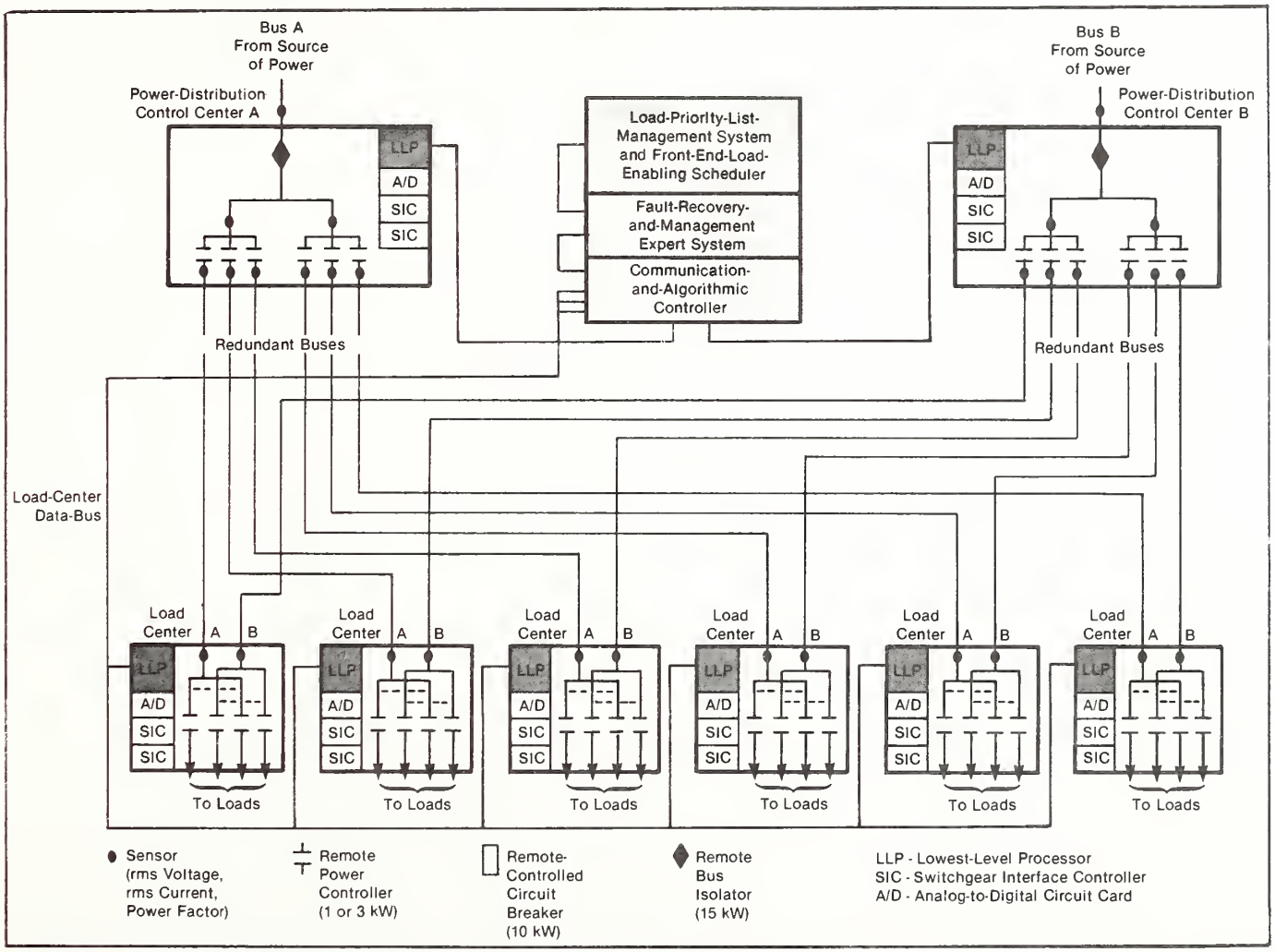


Figure 1. **The Autonomous Power-distribution System** includes power-control equipment and automation equipment. The system automatically schedules the connection of power to the loads and reconfigures itself when it detects a fault.

The Space Station Module Power Management and Distribution System is a "breadboard" assembly of equipment and computer programs that is being used to develop an automated, autonomous power-distribution system for a proposed space station. When fully developed, the system is expected to allocate and schedule the supply of power to various loads according to changing priorities that it determines, to respond to emergencies, and to diagnose and recover from faults. Potential terrestrial applications of this kind of system include the optimization of the consumption of power in homes, power supplies for autonomous land vehicles and vessels, and power supplies for automated industrial processes.

The system was built in two versions: one for a 20-kHz, 208-Vac source and one for a 120-to-150-Vdc source. In each version, power is supplied from the source through two power-distribution control units and from these units through redundant buses to six load centers (see Figure 1). Each load center supplies power to the loads connected to it according to the schedule generated by the system. When the system detects a short circuit or other fault in one of the loads, it does not merely turn off power to that load: it reconfigures itself while continuing to operate and reschedules its activities in a manner that takes account of the fault.

From a system-architectural point of view, the system can be classified as consisting of multiple distributed hardware and software agents. The hardware comprises two distinct elements. One element is the power-control equipment through which current flows to the loads. This element includes analog equipment and the digital low-

est-level processors in the power-distribution control units and load centers. The other hardware element is the automation equipment, which includes computers and process-oriented circuit cards that do not handle the current being distributed.

The partition and distribution of software functions provide the capability for real-time control that blends artificial-intelligence processing (which is slow) for high-level functions (e.g., diagnosis and scheduling) with deterministic processing (which is fast) for low-level functions (e.g., detecting a short circuit and switching off power pending diagnosis and rescheduling at the high level). The architecture of the software takes advantage of the architecture of the hardware in that the deterministic components of software reside in the distributed processing equipment connected directly to the power-control equipment in the power-distribution control units and load centers. Slower artificial-intelligence application programs reside farther from this power-control equipment, the slowest being the farthest in terms of the hierarchical relationships among the components of software (see Figure 2). This system concept provides a "crisp" command structure close to the power-control equipment and a more refined reasoning structure that takes over when time allows.

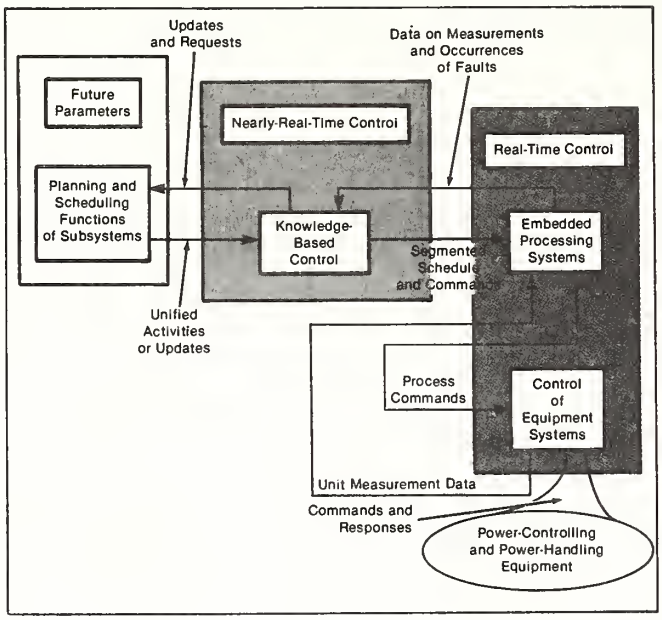


Figure 2. The **Hierarchical Relationships** among the computer programs that reside in different pieces of equipment provide both rapid response to emergencies and faults and the benefits of artificial intelligence, which performs diagnosis, scheduling, and reconfiguration at a more leisurely pace.

This work was done by Barry Ashworth, Joel Riedesel, Chris Myers, William Miller, Ellen F. Jones, Kenneth Freeman, Richard Walsh, Bryan K. Walls, David J. Weeks, and Robert T. Bechtel of Martin Marietta Corp. for **Marshall Space Flight Center.** *For further information, Circle 65 on the TSP Request Card.*
MFS-28504/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

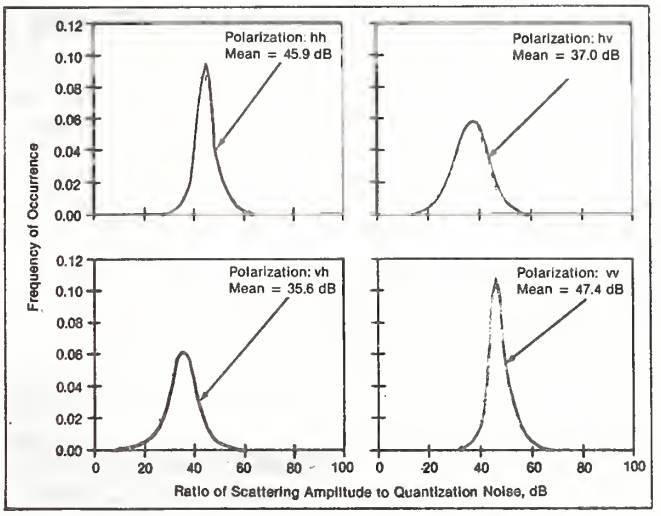
Algorithms for Compression of Polarimetric-Radar Image Data

Data on background noise and effects of equipment are retained.

Two sets of algorithms provide moderate improvements in the compression and decompression of scattering-matrix data from a polarimetric imaging radar system. The purpose of a data-compression algorithm is to facilitate processing by reducing the volume of polarimetric image data while preserving the properties of the original collection of scattering matrices (one such matrix for each of the picture elements in the original radar image). The accompanying decompression algorithm reconstructs approximations of the scattering matrices from the compressed data.

The data-compression algorithms differ from a prior-compression algorithm in two important respects: (1) whereas the prior algorithm operated on four-look Stokes-matrix averages of the original single-look data, the present algorithms operate on the original single-look scattering matrices; (2) on the basis of assumed reciprocity, the prior algorithm symmetrized the scattering matrices before compression, with consequent loss of data on background noise and nonreciprocity in the transmitting and receiving equipment. The present algorithms do not symmetrize the scattering matrices and, therefore, preserve asymmetrical data on background-noise and equipment effects.

The two present sets of algorithms differ from each other only in the number of bits used to quantize the data — 8 bits in one case, 4 bits in the other. In the first step of either compression algorithm, the complete set of scattering-matrix data for all picture elements is scaled by a single factor, called the "general scale factor." This factor is chosen so that the average, over all picture elements, of the total scattering power of each picture element is unity. As used here, the total scattering power of a picture element is defined as $\frac{1}{4}(|S_{hh}|^2+|S_{hv}|^2+|S_{vh}|^2+|S_{vv}|^2)$, where the S's denote the scattering amplitudes (elements of the scattering matrix), the first subscript denotes the receiving polarization, the second subscript denotes the transmitting polarization, h denotes "horizontal," and v denotes "vertical."



The **Signal-to-Noise Ratios** of compressed data in these histograms are computed from 8-bit-quantized scattering amplitudes and quantization noise from a 768,000-pixel polarimetric radar image of Goldstone Dry Lake in California. The average signal-to-noise ratio is greater than that of a data-compression scheme based on the Stokes-matrix formulation.

Next, the scaled total scattering power for each scattering matrix is coded into two bytes: one for the exponent and one for the mantissa. This provides a dynamic range of 765 dB in 8-bit quantization or 63 dB in 4-bit quantization — more than adequate for the dynamic range of typical total-scattering-power data, which is less than 30 dB.

Continuing the process of quantization within each scattering matrix, each scattering amplitude is divided by the quantized value of $(|S_{hh}|^2+|S_{hv}|^2+|S_{vh}|^2+|S_{vv}|^2)^{1/2}$, so that the real and imaginary parts of the matrix elements thus normalized lie in the range from −1 to +1. During the 8-bit compression, each real and imaginary normalized value is multiplied by 127 and coded as one byte. During the 4-bit compression each real and imaginary normalized value is multiplied by 7, and each pair of real and imaginary numbers is coded as one byte. The dynamic range of this quantization is 48 dB in the 8-bit case or 24 dB in the 4-bit case, and is in addition to the 765-dB (8-bit) or 63-dB (4-bit) range of the general-scale-factor quantization.

The 8-bit version divides the volume of data by a factor of 3.2, while the 4-bit version divides the volume by a factor of 6.4. The major disadvantage of these compression algorithms is that they introduce a small amount of quantization noise (see figure for the 8-bit results).

This work was done by Jacob J. Van Zyl and Charles F. Burnette of Caltech for **NASA's Jet Propulsion Laboratory.**
NPO-18240/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and
Space Administration
Ames Research Center, Moffett Field, California

Simulation of Static and Moving Acoustical Sources

Sounds in headphones are even changed according to movements of the listener's head.

A signal processor generates three-dimensional sound cues for headphones. It provides up to four independent acoustical sources simultaneously and simulates the movements of each source in real time. It can be used to enhance presentations of data in the cockpits of airplanes, in air-traffic-control towers, for training people whose hearing is impaired, for monitoring telerobots in hazardous situations, and for visualizing multidimensional scientific data, among many possible applications.

The processor simulates three-dimensional motion by synthesizing sound waves that are tailored to the specific characteristics of a listener's ears. Its waveforms are thus nearly identical to those that would be produced by free-field sound sources. The synthesis is based on head-related transfer functions—the listener-specific, direction-dependent functions that express the acoustic effects imposed on incoming signals by the outer ears. Head-related transfer functions are measured as finite-impulse responses with small probe microphones placed near the two eardrums of a listener in an anechoic chamber. These measurements are taken with a source of sound at each of 144 different locations at intervals of 15° in azimuth and 18° in elevation. A map of finite-impulse-response location filters is then constructed from the 144 binaural pairs of finite-impulse responses.

The map data are fed to a digital processor, the convolvotron, that convolves the digitized version of an analog signal with location-filter coefficients based on the coordinates of the source of the signal and the position and orientation of the listener's head. This places the signal in the listener's perceptual three-dimensional space. The processor can handle more than 300 million multiplication-and-accumulation operations per second.

The system monitors the position and orientation of the listener's head and uses the resulting data to maintain a fixed apparent position for a static source or an accurate trajectory for a moving source, regardless of how the head moves. Inasmuch as a listener often turns toward a localized source of sound, this adds to the verisimilitude of the simulation.

The processor simulates locations of sources of sound with a resolution greater than that of the measurements on which the finite-impulse response are based by interpolating between measurement positions with linear weighting functions. Studies have shown that listeners cannot distinguish signals interpolated between sources as far apart as 60°in azimuth from those synthesized from measurements.

This work was done by Elizabeth M. Wenzel of **Ames Research Center,** *Scott H. Foster of Crystal River Engineering, and Frederic L. Wightman and Doris J. Kistler of the University of Wisconsin.*
ARC-12768/TN

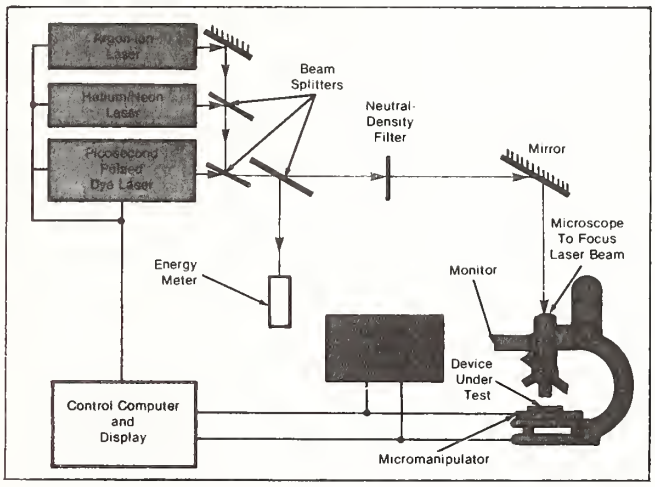
FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Single-Event-Upset Laser Scanner With Optical Bias

Additional steady illumination increases vulnerability to upset in the insensitive mode.

The light-assisted microelectronic advanced laser scanner (LAMEALS) is an augmented version of the microelectronic advanced laser scanner (MEALS) described in the preceding article, "Laser Scanner Tests for Single-Event Upsets." The only major difference is that in the LAMEALS, steady illumination from a helium/neon laser, argon-ion laser, and/or other source(s) is combined with the pulsed dye-laser illumination of the MEALS into a single illuminating beam (see figure). As in the MEALS, this beam is focused onto a small spot on the device under test. The steady component of the illumination can be regarded as an optical bias. The response of the device under test to this bias can provide additional data to characterize the device.



The **Light-Assisted Microelectronic Advanced Laser Scanner** adds steady illumination (optical bias) to the probing spot of light on the device under test. In other respects, it is essentially the same as the microelectronic advanced laser scanner described in the preceding article.

Effects of optical bias were observed in tests of an n-type metal oxide semiconductor 256K dynamic random-access memory. When the memory was in the insensitive mode (all cells discharged to the "zero" state), the pulsed laser light alone below a certain intensity could not upset the memory. However, when an optical bias of about 20 kW/cm^2 (produced by focusing a 5-W, 632.8-nm steady laser beam) was applied to a storage capacitor in the memory, the pulsed laser light did cause upsets. In addition, it was found that the memory could be upset by the optical bias alone.

This work was done by Quiesup Kim of Caltech for **NASA's Jet Propulsion Laboratory.** *NPO-18217/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

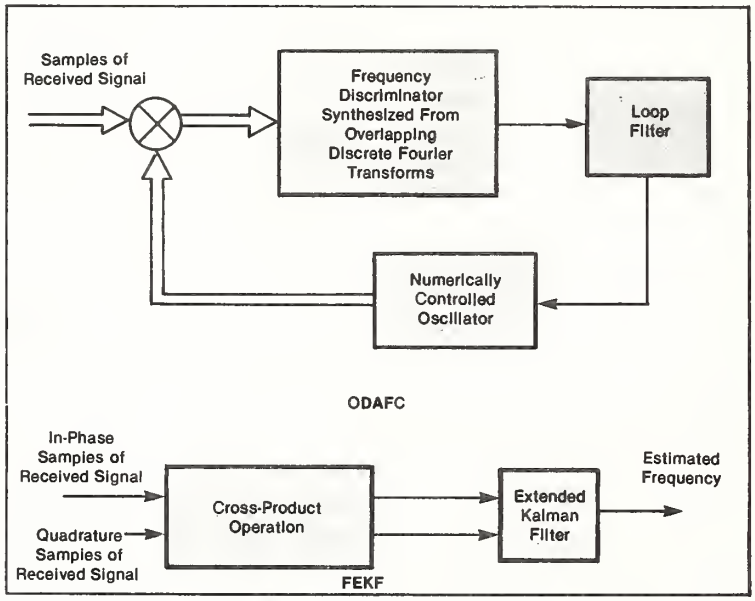
Two AFC Loops for Low CNR and High Dynamics

Tracking abilities lie between those of a cross-product AFC loop and of a maximum-likelihood estimator.

Two alternative digital automatic-frequency-control (AFC) loops have been proposed to acquire (or reacquire) and track the frequency of a received carrier radio signal. The loops are intended for use where the carrier-to-noise ratios (CNR's) may be low and carrier frequency may be characterized by a high Doppler shift and Doppler rate because of high relative speed and acceleration, respectively, between the transmitter and receiver. Either of the proposed AFC loops would be used in place of a phase-locked loop, which cannot operate under such conditions. The new loop concepts integrate ideas from classical spectrum-estimation, digital-phase-locked-loop, and Kalman-Filter theories.

The optimum carrier-frequency-tracking loop (a maximum-likelihood estimator) is impractically complicated and would require an excessive amount of computation. The proposed AFC loops are based on suboptimum frequency-estimation strategies selected to obtain acceptable compromises between the desirability of low operating CNR threshold and good tracking performance on the one hand and the undesirability of complexity and much computation on the other hand. These loops would be generalizations of the cross-product frequency-control loop.

The first frequency-estimation scheme (see figure) is called "overlapping-discrete-Fourier-transform-based automatic frequency control" (ODAFC) loop. In this scheme, running, overlapping discrete Fourier transforms would be used to implement a frequency discriminator. In the absence of noise, the output of this discriminator would be nearly proportional to the error in the estimated frequency for errors up to about one-tenth the sampling frequency.



These **Proposed Carrier-Frequency-Tracking Loops** would operate under low-noise, high-Doppler-rate conditions in which phase-locked loops do not work.

The second frequency-estimation scheme is called "frequency-estimator extended Kalman filter" (FEKF). In this scheme, the received signal would first be preprocessed in a cross-product operation like that of a cross-product AFC loop to eliminate the phase information. (The reason for this is that it can be inferred from some previous studies that a tracking loop that eliminates the phase information first might be able to operate at a slightly lower minimum signal-to-noise ratio than does one that estimates the phase also.) The preprocessed samples would then be fed to the extended Kalman filter.

Each of the proposed AFC loops offers a distinct advantage. The ODAFC would create a superior discriminator characteristic, whereas the FEKF would provide a superior loop filter. Computer simulations show that these loops can operate at lower carrier-to-noise ratios (albeit with greater root-mean-square frequency errors) than do other popular tracking AFC loops. The performances of these loops were found to lie between those of a typical cross-product AFC loop and of a maximum-likelihood estimator.

This work was done by Sami M. Hinedi and Sergio Aguirre of Caltech for **NASA's Jet Propulsion Laboratory.**
NPO-17793/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Ames Research Center, Moffett Field, California

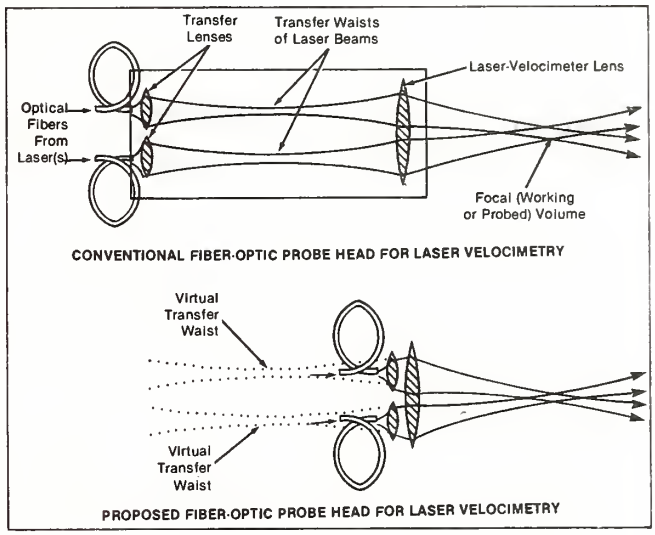
Licensing Opportunity

Fiber-Optic Probe for Laser Velocimetry

The size and weight of optics would be reduced considerably.

A proposed fiber-optic probe in a laser velocimeter would be smaller (and, therefore, lighter in weight and more maneuverable) than previous such probes have been. Typically, an optical-fiber probe is used in the transmitting optics of a laser velocimeter to enable the laser-velocimeter lens to be moved to scan the probing beams across the test volume while the laser(s) and associated optical components remain fixed. This reduces the number and weight of optical components that have to be moved. However, the positions and orientations of the lenses and the output ends of the fibers in the probe head must be maintained precisely, and the distance between the ends of the fibers and the laser-velocimeter lens can be large — of the order of meters. Thus, even though a conventional fiber-optic probe head does not have to carry the laser(s), it must nevertheless be made relatively large and heavy to maintain the necessary optical alignments.

The optical configuration of a fiber-optic probe head for laser velocimetry is dictated by the required working distance (approximately the focal length of the laser velocimeter lens) and the need to make the waists of the intersecting laser beams have the proper diameter and location. Usually, one needs waists as narrow as possible, located in the working volume at the intersection of the beams. As shown in the top part of the figure, the conventional optical configuration requires a transfer lens for each laser beam and a transfer waist located in each beam between the transfer lens and the laser-velocimeter lens. The length of this configuration exceeds the focal length of the laser-velocimeter lens.


Transfer Lenses
Transfer Waists of Laser Beams
Laser-Velocimeter Lens
Optical Fibers From Laser(s)
Focal (Working or Probed) Volume
CONVENTIONAL FIBER-OPTIC PROBE HEAD FOR LASER VELOCIMETRY
Virtual Transfer Waist
Virtual Transfer Waist
PROPOSED FIBER-OPTIC PROBE HEAD FOR LASER VELOCIMETRY

The **Proposed Fiber Optic Probe Head** would be more compact and, therefore, lighter in weight and more maneuverable.

The proposed configuration, illustrated in the bottom part of the figure, is the product of calculations and experiments that show that the beams do not have to be focused to real waists before they pass through the laser-velocimeter lens: virtual waists can serve the same purpose. By appropriate repositioning of the transfer lenses, one could obtain virtual waists behind the transfer lenses, back along their optical axes toward the sources of light. The laser-velocimeter lens could then be brought close to the transfer lenses to focus on the virtual waists, thereby shortening the probe head considerably.

This work was done by Dana H. Lynch and Kenneth W. McAlister of **Ames Research Center** *and William D. Gunter, Jr., of Photon Applications.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center. Refer to ARC-11889/TN.

Ames Research Ctr.
Technology Utilization Officer: Geoffrey S. Lee
Mail Code 223-3
Moffett Field, CA 94035
(415) 604-4044
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Energy

0489 Low-Temperature Hot Water Heat Distribution Systems

Other Items of Interest

0480 Electrochromatic Optical Switching Device (Licensing Opportunity)

Fact Sheet

LOW-TEMPERATURE HOT WATER HEAT DISTRIBUTION SYSTEMS

PROBLEM

Currently, most DoD facilities are heated with central heat distribution systems that use either high-temperature water or steam to convey the heat. Nearly 6,000 miles of these systems are in place on DoD facilities. These systems have proven to be problematic and in some cases very inefficient. It is estimated that heat losses from these systems cost the Army more than $100 million per year. Additionally, the 1988 "Redbook" gives annual maintenance costs of approximately $41 million for the Army alone.

SOLUTIONS

Low-temperature hot water systems have been widely used in Europe for many years and now are gaining acceptance in the United States by the private sector. The low-temperature materials and procedures have reduced the cost of these systems so that a cost advantage may be possible when replacing deteriorated steam and high-temperature water systems. Many of the improved materials and methods used in the low-temperature systems are not suitable for high-temperature water or steam systems.

Benefits of the low-temperature systems include increased efficiency of heat distribution, reduced maintenance due to lower temperature and pressure, and improved materials that can be used only at these lower temperatures. Low temperatures and pressures also result in increased safety for service personnel and building occupants. Heat loss can be reduced from twenty percent or more to less than five percent of system capacity. Mass losses due to leakage can be reduced almost to zero, compared to make-up rates of fifteen percent or more for good steam systems. For example, a CRREL study has shown that the Hawthorne AAP steam system has a make-up rate of more than fifty percent.

RESULTS

At Fort Irwin, California, a low-temperature hot water system has been installed as part of a new barracks complex. CRREL has instrumented this system and will monitor its performance over a period of several years. Data therefrom has been collected for almost three years. To date, results indicate that the heat losses are about thirty-five percent of those from a high-temperature water system being monitored at Fort Jackson, South Carolina.

Because retrofit of existing systems will be very important to DoD, CRREL is seeking a second site where an inefficient steam or high-temperature water system could be replaced with a low-temperature hot water system.

CONTACT

Gary Phetteplace
603-646-4248
FAX 603-646-4640

April 1992

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290

Engineering

0490 Concurrent Engineering Handbook Available on Hypercard

0491 Unmanned Vehicle Available

0492 Acoustic Diagnostics Using a Remotely Operated Vehicle

0493 Pothole Patching

0494 Unsurfaced Road Management System

0495 Adjustably Preloaded Quick-Release Pin—An easy-to-use fastening device is adapted from a commercial product.

0496 Blast-Absorbing Bag—Stitches rip to dissipate explosive energy.

0497 Reflexive Avoidance of Obstacles by Robots—Sensor outputs are processed into synthetic force-field signals that are superimposed on control algorithms. (Licensing Opportunity)

0498 Fiber Jackets for Vibration-Damping Struts—Weak structural elements would be protected from overloads by braided fibers.

0499 Torque Tube Stiffens Trailer Frame—The tube isolates the cargo from twisting moments.

Software

0500 Composite-Blade Structural Analyzer—COBSTRAN computes stresses in blade-like structural components.

Testing & Instrumentation

0501 Instrument Measures Shift in Focus—Optical components can be tested at wavelengths from Ultraviolet to infrared.

0502 Low-Hysteresis Flow-Through Wind-Tunnel Balance—Symmetrical forces caused by internal flow are cancelled.

0503 Multiple-Axis Crosshairs—Three skewed lines provide alignment when viewed along each of three mutually orthogonal axes.

0504 Specimen Holder for Flammability Tests—A frame and clamps are designed to minimize local overstress on the specimen.

U.S. Army Fact Sheet

U.S. Army Industrial Engineering Activity, Rock Island, IL 61299-7260

Concurrent Engineering Handbook Available on Hypercard

Concurrent Engineering (CE) is a systematic and common sense approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and user requirements. By collecting and understanding all requirements that the product must satisfy throughout its life cycle at the start of concept definition, we can reduce cost, avoid costly redesign and rework and shorten the development process.

The McDonnell Douglas Missile Systems Company's (MDMSC) Handbook of Concurrent Engineering provides results, lessons learned, and guidance based on real experience gained on many programs. At MDMSC, four main elements have emerged as most important in implementing CE:

- The voice of the customer,
- Multi-Disciplinary Teams,
- Automated Tools, and
- Process Management.

The underlying purpose of the Handbook is to challenge ourselves to adopt more effective methods that improve the way we do business. The Handbook is intended to define CE, share experiences from various programs, and provide insight on how CE can be tailored to fit program phases and help program managers, teams, team members and proposal writers apply CE.

The conversion of this handbook to disk, and the distribution of the soft copy version, is a product of the PE Tools Program, which is administered by the Production Engineering Division, U.S. Army Missile Command, Huntsville, Alabama. This application utilizes Hypercard, a common application accompanying most MacIntosh computer systems.

FOR MORE INFORMATION or a free copy of the MDMSC Handbook of Concurrent Engineering, contact:

University of Alabama
Research Institute
RI E-47
Attention: Julie Logan
Huntsville, AL 35899
Telephone (205) 895-633

U.S. Navy Fact Sheet

Naval Weapons Center

Unmanned Vehicle Available

The Naval Weapons Center has acquired the assets from a DARPA/Navy funded program to develop a high performance Unmanned Aerial Vehicle (UAV) capable of remaining airborne for prolonged periods of time with a large payload. The UAV, known as AMBER, has demonstrated 38 hours endurance and a maximum altitude of around 28,000 feet. The Naval Weapons Center has 6 vehicles available that could be utilized in support of missions requiring long endurance, complete with support equipment including a portable ground station. NWC also has a dedicated flight test facility and runway for UAV operations. The AMBER vehicle has a launch weight of 860-1190 lbs with a useful payload weight of 110-440 lbs. The vehicle is designed to carry three payloads simultaneously--Forward Looking Infrared (FLIR), Electronic Support Measures (ESM), and Radio Relay--and could be adapted for other payloads. There are potential applications in drug enforcement, law enforcement, forestry, and land surveying.

For more information, contact John Freeman, (619) 939-3087, or Chuck Newmyer, (619) 939-1074.

Acoustic Diagnostics Using a Remotely Operated Vehicle

The David Taylor Research Center (DTRC), Carderock, Maryland, has developed an Override Noise Measurement System for Acoustic Diagnostic Investigations. The system consists of an acoustic sensor mounted on a computer-controlled, remotely operated vehicle (ROV), a tethered unmanned underwater robot (Figure 2). Any underwater structure or ship hull can be acoustically evaluated by positioning the ROV and hydrophone probe at various locations along the structure where it will measure the sound pressure levels. Different shipboard equipment can be operated to evaluate each system's contribution to the overall acoustic profile. Because the Overside System is capable of measuring the acoustic intensity field in close proximity, it is able to detect and accurately locate noise sources. Corrective action can then be taken to eliminate the noise source.

Typically, ROVs are controlled by an operator who uses hand-held joysticks to activate the ROV's thrusters to achieve the desired vehicle motion. However, the limited underwater visibility and lack of visual reference points for the operator make it necessary to use an underwater navigation system and computer-based controller to accurately position the ROV relative to the hull. The navigation

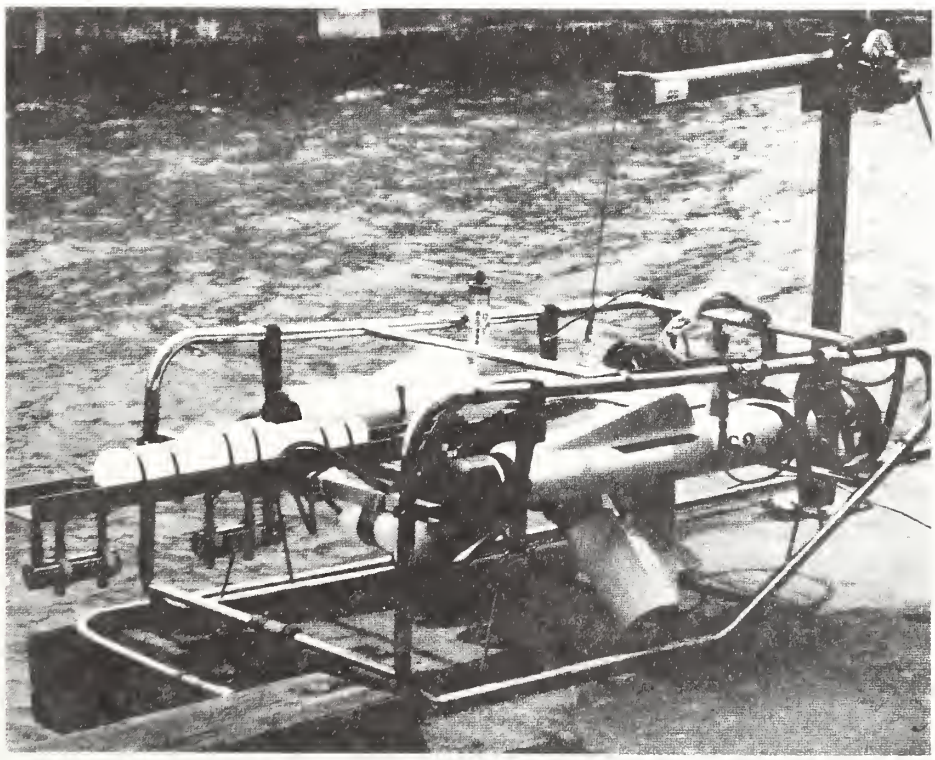


Figure 2. Remotely Operated Vehicle

system obtains the location of each of the transceivers mounted on the ROV and translates it into an ROV position and heading. This position is then compared with the desired position, and the computer activates the appropriate thrusters to move the ROV to the desired position. When the vehicle is at the specified point, the ROV enters a hover phase; the vehicle will maintain that position until instructed to move. A computer data file of desired hover points along the hull can be created ahead of time, and at the time of deployment, the vehicle can be commanded to go to any of these points.

The ROV's acoustic probe consists of a boom from which two dual element, phase method, hydrophones are resiliently mounted to form a line array. The relative spacing between the hydrophone elements is preset and determined by the frequency range to be measured.

While taking acoustic measurements, the ROV follows a path defined by a matrix of grid points that describe an imaginary control surface one meter away from the structure. The ROV then measures the sound pressure levels and phase angle between both hydrophones as it hovers at each grid point. A dynamic signal analyzer is used to extract sound intensity from these measurements, which allows the operator to assess predominant frequencies and levels while the measurements are in progress. The intensity data from each grid point are then summed over the entire grid and post-processed to develop sound intensity contour plots. These sound intensity contours can be superimposed on an outline of the structure to ease interpretation of the acoustic survey's results. The Overside System can be used in a harbor or pier side environment because of the sound intensity method's ability to discriminate against background noise. The integration of the positioning system with the computer-based control system allows us to position the ROV very accurately in zero visibility conditions. The Overside System is portable and can be deployed rapidly at any port without support from shipyard personnel. As a result, acoustic diagnostic work can be performed with minimal impact on schedules.

For Additional Information:

Backup material on this effort is available from:

Navy Domestic Technology Fact Sheet Reader Reply Service
Code E211
Naval Surface Weapons Center
Dahlgren, VA 22448-5000
(703) 663-8921

Refer to 161202/TN

Fact Sheet

POTHOLE PATCHING

PROBLEM

Current pothole repair methods are costly and ineffective. Temporary patching that lasts only days or even hours is not a proper use of resources and can cost up to five times as much annually as one-time permanent patches.

SOLUTION

A CRREL research team has evaluated commercially available equipment that can recycle currently wasted hot mix asphalt concrete thrown away after summer maintenance repairs. This equipment can reheat asphalt concrete year-round and can provide hot mix for potholes in the late fall, winter, or spring during "pothole season" when hot mix plants are closed. The equipment also can heat cold patch materials.

RESULTS

By using this equipment and currently available trucks, compactors, and pavement breakers, permanent one-shot repairs are possible, thereby saving time, resources, and money.

The following reports and videotape generated by this project explain proper pothole repairs in detail.

Pothole Primer—A Public Administrator's Guide to Understanding and Managing the Pothole Problem, CRREL Special Report 81-21, revised April 1985

The Engineer's Pothole Repair Guide, CRREL Cold Regions Technical Digest 84-1

Comparison of Three Compactors Used in Pothole Repair, CRREL Special Report 84-31

A videotape, *Potholes—Causes, Cures and Prevention*, 11 minutes, is also available.

These products are free and may be obtained by writing:

Publications
USACRREL
72 Lyme Road
Hanover, New Hampshire 03755-1290

CONTACT

Robert Eaton
603-646-4209
FTS 561-4209
FAX 603-646-4640

January 1992

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

Fact Sheet

UNSURFACED ROAD MANAGEMENT SYSTEM

DESCRIPTION

In July 1984, the Federal Highway Administration funded CRREL under its Rural Transportation Assistance Program (RTAP) to "Revise the PAVER Pavement Management System for Use on Unpaved Roads." Additional funding was provided by four Army agencies. By working with CERL, WES, FORSCOM, TRADOC, EHSC, Tulsa District Corps of Engineers, and others, a rating system for unsurfaced roads was developed and field-validated. It has been incorporated into micro-PAVER with distresses numbered 81-87.

The method has been implemented at Fort Riley, Kansas; Fort Carson, Colorado; Fort Wainwright, Alaska; and Fort Greeley, Alaska. Fort Ord, California, also was surveyed.

PROGRAM OBJECTIVES

a. Perform evaluations of all unsurfaced roads, range roads, tank trails, and other areas to support mission requirements.

b. Maintain these facilities to minimum acceptable levels.

c. Provide a complete management system for surfaced as well as unsurfaced roads.

OUTPUTS

a. *Rating Unsurfaced Roads* manual, CRREL Special Report 87-15, September 1988.

b. *Development of the Unsurfaced Roads Rating Methodology*, CRREL Special Report 88-5, January 1989.

c. Videotapes: three aimed at administrators, facility engineers, and raters, 1989.

BENEFITS

This system allows manual and/or computerized pavement maintenance management at military facilities for both surfaced and unsurfaced roads. It has been incorporated into micro-PAVER.

CONTACT

Robert A. Eaton
U.S. Army Cold Regions Research and Engineering Laboratory
72 Lyme Road, Hanover, New Hampshire 03755-1290
Commercial: 603-646-4209/4405
FAX 603-646-4640 (To verify reception, use extension 4405.)

Ron Beaucham
U.S. Army Engineering and Housing Support Center
Commercial: 703-704-1576
FAX 703-704-1610

February 1992

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

CRREL, 72 Lyme Road, Hanover, NH 03755-1290

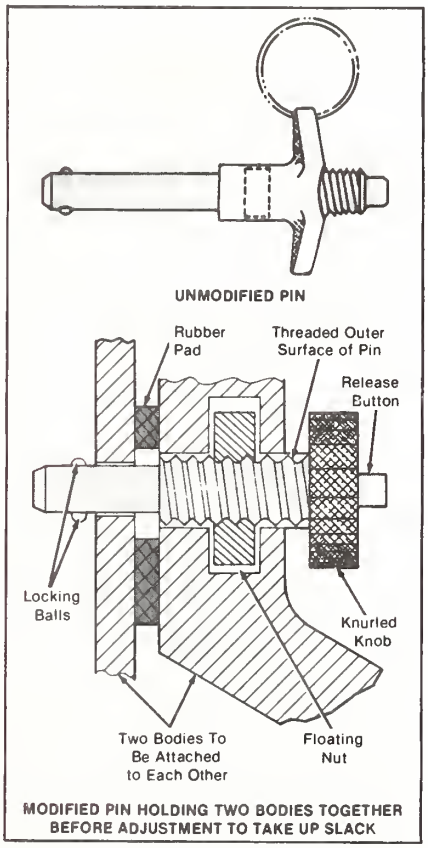
NASA Tech Brief
National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Adjustably Preloaded Quick-Release Pin

An easy-to-use fastening device is adapted from a commercial product.

An attachment pin connects and disconnects rapidly and can be adjusted to accommodate small differences between the thicknesses of nominally identical sets of parts to be attached to each other. The pin is a modified version of a commercial ball-locking fastener that is sometimes called a "pip" pin.

In its modified form, the pin can be preloaded slightly in tension as though it were a bolt. The T-shaped handle of the unmodified version is removed from the threaded end of the pin opposite the locking-ball end. In its place, a knurled knob is secured with a setscrew on a flat spot on the otherwise threaded surface. A floating nut that fits into a slot on one of two bodies that are to be attached to each other engages the threaded surface on the pin.


UNMODIFIED PIN
Rubber Pad
Threaded Outer Surface of Pin
Release Button
Locking Balls
Knurled Knob
Two Bodies To Be Attached to Each Other
Floating Nut
MODIFIED PIN HOLDING TWO BODIES TOGETHER BEFORE ADJUSTMENT TO TAKE UP SLACK

The **Modified Adjustable-Grip-Length Quick-Release Pin** holds two bodies together. The threaded shaft of the pin is threaded in the floating nut to pretension the fastener.

To insert the pin, the user presses the button on the end of the pin opposite the balls to retract the balls, places the pin through the two bodies to be attached to each other, and releases the button to push the balls back out to the locking position. The user then turns the knurled knob to thread the pin in the floating nut until the slack is taken up, and rubber pads between the bodies to be attached to each other are compressed slightly. To extract the pin, the user simply presses the button to retract the locking balls and pulls the pin out.

This work was done by Harold W. Reimers of **Johnson Space Center**. *MSC-21753/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Blast-Absorbing Bag

Stitches rip to dissipate explosive energy.

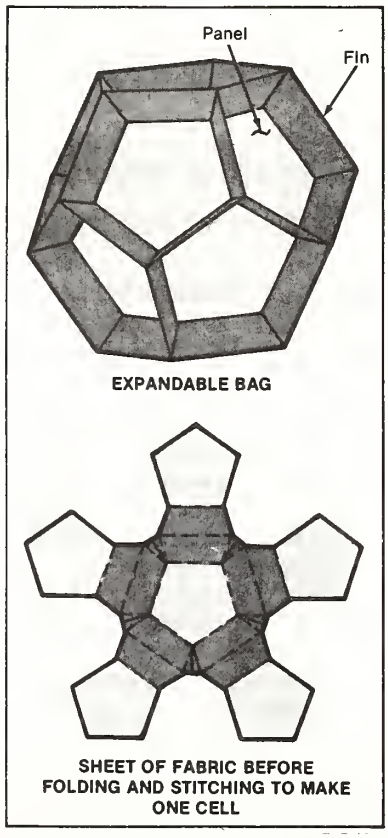
A proposed expandable bag would contain debris from an explosion. The bag could permanently surround a vessel or devices prone to explosive disintegration (e.g., a pressurized tank), or it could be slipped around a small bomb.

The bag would consist of cells of a strong, flexible fabric like Kevlar (or equivalent) aromatic polyamid, stitched together to form an externally finned polyhedron (see figure). Each cell would be made of contiguous sheets of fabric, cut, folded, and stitched together in overlapping layers.

When an explosion occurred within the bag, sets of stitches would be ripped in progression by the expanding gas, absorbing the energy of the explosion as they tore. As the stitches in the fins between cells broke, the cells would change from outward-opening cups to inward-opening bubbles. However, the stitches that joined the cells would be stronger and would resist the force of the explosion so that the bag would remain intact and retain the debris of the explosion.

If the bag is to be used to dispose of a bomb, one or more cells must be removable so that the bomb can be placed in it. For this purpose, panels could be equipped with a draw cord, bolt plates, hooks, zippers, or other fastening devices for quick and easy opening and closure.

This work was done by Jon B. Kahn of **Johnson Space Center.**
MSC-21666/TN



Finned Cells would be shaped like outward-opening cups. Cells would be built up from overlapped sheets of fabric and stitched together to form an expandable polyhedral bag. Cells may be pentagonal, as shown here, or else triangular or square.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Langley Research Center, Hampton, Virginia

Licensing Opportunity

Reflexive Avoidance of Obstacles by Robots

Sensor outputs are processed into synthetic force-field signals that are superimposed on control algorithms.

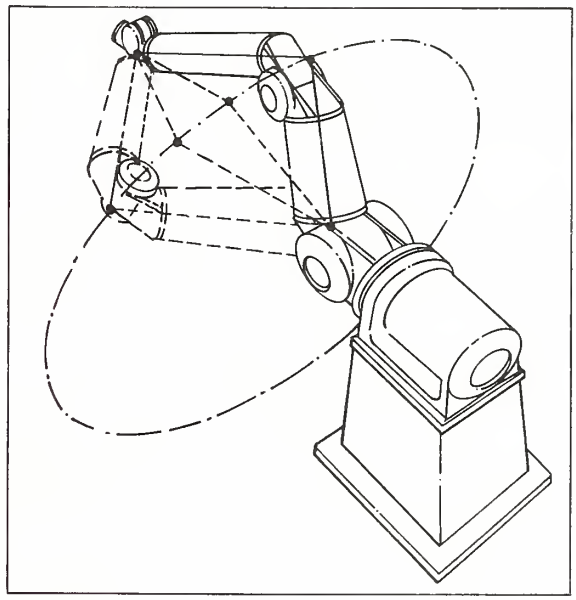
The National Aeronautics and Space Administration has identified a number of promising applications for advanced robots and telerobots in future space operations. The most sophisticated of these robots will be required to perform complex tool-handling tasks with dexterity nearly equivalent to that of humans while operating with a minimum of human intervention.

These telerobots will generally have more than six joints apiece operating under simultaneous, coordinated control. Seven is the minimum number of axes required in a mechanical manipulator to imitate the basic motions of the human arm, from the shoulder to the wrist. Like the human arm, a seven-degree-of-freedom manipulator can assume any number of different joint configurations, or arm poses, for a given position and orientation of the "hand," or toolpoint.

With one redundant degree of freedom, the manipulator arm has the freedom to reach around and avoid collisions with objects in certain locations in its workplace while it performs its programmed task. The more redundant degrees of freedom incorporated in the manipulator system, the more versatility it has. To perform extremely complex tasks with true "man equivalence," future space telerobots may eventually incorporate hundreds of degrees of freedom operating under coordinated control.

Research was conducted to develop a reflexive obstacle-avoidance system for kinematically redundant manipulators equipped with proximity sensors mounted on the manipulator arms to control the poses of the arms. Specific objectives of research projects included the evaluation of alternate proximity-sensor technologies, the development of algorithms to translate sensor data into penalty functions that represent obstacles, and the demonstration of a prototypical system. Proximity-sensor technologies were surveyed and evaluated for both Earth and space applications.

A seven-degree-of-freedom (dextrous) manipulator and a motion controller served as the laboratory test bed for interactions with sensors and the implementation of algorithms. Equations were developed and coded to modify dynamically the objective functions used by the standard redundant motion-control algorithm of the manipulator such that an object detected by arrays of sensors located at the elbow effectively applies a "force" to the elbow, along its rotational axis. The elbow is thus "repelled" by objects detected by the sensors, causing the robot to steer its elbow around the objects in the workspace automatically while continuing to move its tool along the commanded path without interruption.



An **Array of Sensors at the Elbow** of this robotic manipulator detects obstacles. The outputs of the sensors are processed into a synthetic "force field" around each obstacle. The algorithm that controls the manipulator uses the "force field" to maneuver the manipulator arm around each obstacle.

Signals transmitted by each sensor in the arrays mounted on the elbow to the control unit are processed to add vectorially the largest forces, as reflected by the closest objects, on either side of the manipulator and to apply the resultant force along the rotational axis of the elbow (see figure). This scheme enables the arm to center itself between objects detected on either side of the elbow joint or on both sides simultaneously. In addition, the forcing function varies exponentially with distance, so that objects detected at close range cause a much more rapid movement of the arm away from an impending collision. While this effort is aimed primarily at avoiding collisions with external objects detected in the workspace, the principle applies equally well to the detection and avoidance of collisions between different members of the manipulator itself.

The mathematical approach to the translation of proximity-sensor inputs into additional redundant control criteria is extensible to massively redundant systems of any topology. The more redundant the system, the more valuable sensor-driven reflexive avoidance of obstacles becomes. For space servicing systems like the NASA Flight Telerobotic Servicer, it may be impossible to perform the planned operations without such a system.

Also, the avoidance of collisions in real time is implemented as a critical safety subsystem. The FTS, for instance, has requirements for a means to ensure that the telerobot cannot injure an astronaut who inadvertently drifts into the working envelope, and to ensure that the telerobot cannot damage fragile spacecraft hardware by unplanned collisions. In addition, opportunities for the use of redundant robots in automated factories would be expanded substantially if a reflexive obstacle-avoidance system became commercially available. The use of off-line programming for redundant manipulators and associated work-cell-design time would be greatly reduced with an obstacle-avoidance system to select the poses of arms dynamically

and without explicit programming intervention by the operator.

This work was done by Havard I. Vold, and James D. Farrell of Robotics Research Corp. for **Langley Research Center**. *No further documentation is available.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

James P. Karlen
Robotics Research Corp.
5400 DuPont Circle
Milford, OH 45150

Refer to LAR-14135/TN

Langley Research Ctr.
Technology Utilization Officer: Joseph J. Mathis, Jr.
Head, TU & AO Office
Mail Stop 200
10 West Taylor Road
Hampton, VA 23665-5225
(804) 864-2484
Patent Counsel:
Dr. George F. Helfrich
Mail Stop 143
9A Ames Road
Hampton, VA 23665-5225
(804) 864-3221

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

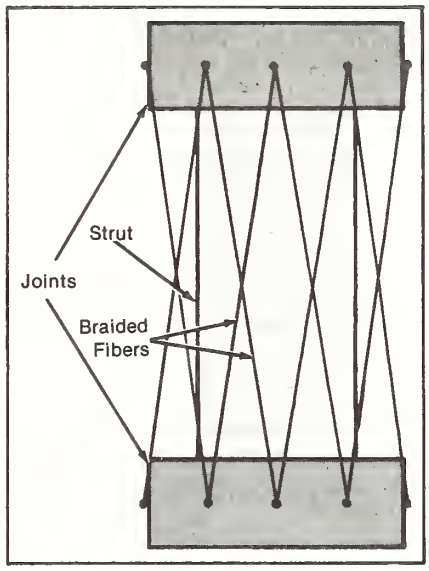
NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Fiber Jackets for Vibration-Damping Struts

Weak structural elements would be protected from overloads by braided fibers.

Fiber jackets have been proposed for use in protecting elastomeric and other vibration-damping struts against excessive loads. Such struts can be damaged by excessive stretching in transit, during which loads and displacements can exceed the relatively small displacements for which the struts were designed.

A typical proposed jacket would consist of braided fibers (see figure) of a material (e.g., graphite or a suitable polymer) of high specific strength. Although unidirectional fibers could be used instead, braided fibers would be preferred because of the greater ease with which a braided-fiber jacket can be manufactured, handled, and attached to structural joints at the ends of a strut. On the other hand, a comparable jacket of straight fibers could carry a load 5 to 10 percent larger.



A **Jacket of Braided Fibers** would be fastened to structural joints at the ends of a strut. The jacket would carry excessive tensile loads, partly bypassing the strut.

Friction between braided fibers would give rise to a hysteresis in the stress-versus-strain behavior of a jacket. The hysteresis would enhance the absorption of large vibrations.

A jacket would absorb only tensile loads. To protect a strut against both high compressive and high tensile loads, it would be necessary to install two fiber jackets, supported from opposite lengthwise directions.

This work was done by Benjamin P. Dolgin of Caltech for **NASA's Jet Propulsion Laboratory.**
NPO-18161/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

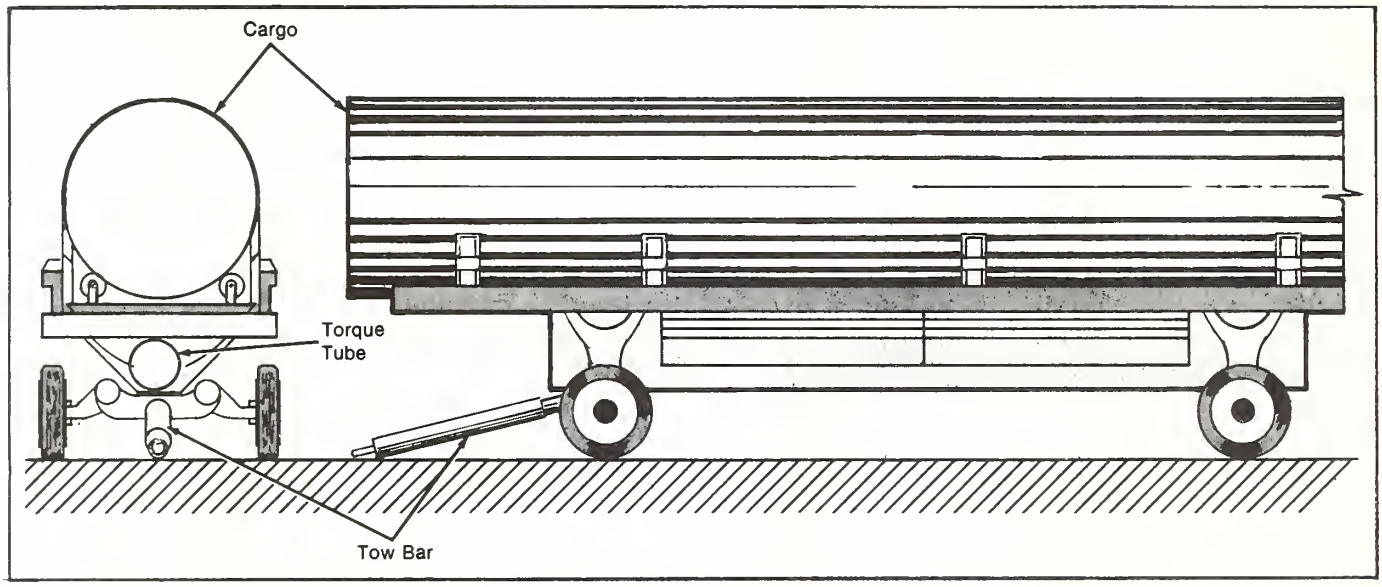
Torque Tube Stiffens Trailer Frame

The tube isolates the cargo from twisting moments.

A reinforced trailer frame absorbs torsion, preventing it from being transmitted to the cargo. The reinforcement is needed in this particular trailer because it is of hard-axle design, without springs or shock absorbers.

The trailer frame incorporates a longitudinal torque tube that absorbs torsional loads and stiffens the trailer (see figure). The torsion frame can be used to transport large cylindrical objects like pressure vessels, tanks, and rocket engines without subjecting them to damage or excessive loads.

This work was done by Malcolm J. MacMartin of Caltech for **NASA's Jet Propulsion Laboratory.**
NPO-18314/TN



The **Torque Tube Is Held** by plates over the axles.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration

Computer Software

Composite-Blade Structural Analyzer

COBSTRAN computes stresses in blade-like structural components.

The COBSTRAN (COmposite Blade STRuctural ANalyzer) computer program is a preprocessor and postprocessor that facilitates the design and analysis of composite turbofan and turboprop blades, and of composite wind-turbine blades. COBSTRAN combines the theories of the mechanics of composites and of laminates with a data base of fiber and matrix properties.

As a preprocessor for NASTRAN or another finite-element-method (FEM) program, COBSTRAN generates an FEM mathematical model with anisotropic, homogeneous material properties. The stress output from the FEM program is provided as input to the COBSTRAN postprocessor. The postprocessor then uses the composite-mechanics and laminate-theory routines to calculate individual ply stresses, strains, interply stresses, through-the-thickness stresses, and failure margins.

COBSTRAN is designed to carry out the many linear analyses required for the efficient mathematical modeling and analysis of bladelike structural components made of multilayered angle-plied fiber composites. Components made from isotropic or anisotropic homogeneous materials can also be modeled as special cases in COBSTRAN. NASTRAN MAT1 or MAT2 material cards are generated according to properties supplied by the user.

COBSTRAN is written in FORTRAN 77 and was implemented on a CRAY X-MP computer with a UNICOS 5.0.12 operating system. The program requires either COSMIC NASTRAN or MSC NASTRAN as a structural-analysis software package. COBSTRAN was developed in 1989 and requires a memory of 262,066 64-bit words.

This program was written by R.A. Aiello and C.C. Chamis of **Lewis Research Center.** *LEW-14992/TN*

FOR ADDITIONAL INFORMATION

CONTACT

COSMIC®
112 Barrow Hall
University of Georgia
Athens, GA 30602

(404) 542-3265

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Instrument Measures Shift in Focus

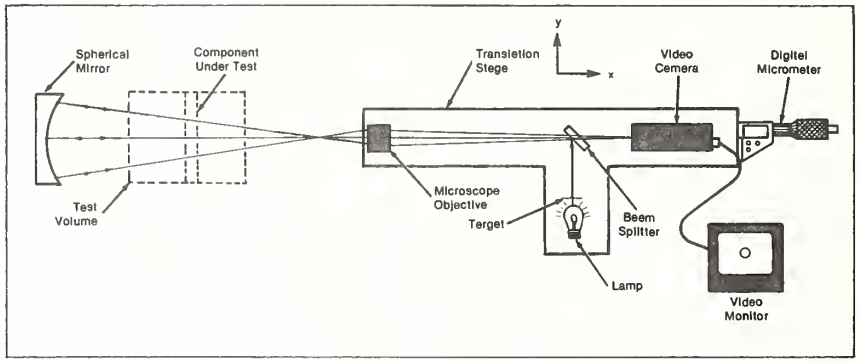
Optical components can be tested at wavelengths from ultraviolet to infrared.

An instrument measures the distance along which the focal point of a converging beam of light is shifted by the introduction of a nominally plane parallel optical component into the beam. The instrument is intended primarily for measuring focus shifts produced by windows and filters at wavelengths from 120 to 1,100 nm. It is portable, compact, and relatively inexpensive for its degree of precision.

In the instrument (see figure), an illuminated target is mounted on a precise two-dimensional translation stage along with a reflective microscope objective, a beam splitter, and a charge-coupled-device video camera. The target can be a pinhole, slit, bar pattern, or other pattern suitable for the visual detection of focus or the lack thereof. The microscope objective forms an image of the target at the center of curvature of a spherical mirror.

The spherical mirror reimages the target at its center of curvature. The beam reflected by the spherical mirror serves as the convergent testing beam and has a cone angle large enough to provide the required accuracy in measuring the shift in focus. The microscope objective refocuses the reimaged target from the center of curvature of the spherical mirror onto the focal plane of the video camera.

The translation stage is equipped with a digital micrometer to facilitate measurements of focus shifts. The instrument is brought into focus by adjusting the digital micrometer while observing the image on the video monitor connected to the video camera. This focus adjustment is performed both without and with the optical component under test, and the difference between the micrometer readings in the two cases is recorded. The microscope objective increases the sensitivity of the instrument in that the apparent focus shift is multiplied by the square of the magnification. Thus, the focus shift produced by the component under test equals the difference between the micrometer readings divided by the square of the magnification. In this way, the instrument can measure focus shifts with a repeatability of 0.001 in. (25.4 μm).



The **Focus-Shift-Measuring Instrument** is easy to use. It can be operated in a lighted room, without having to make delicate adjustments while peering through a microscope.

The use of all reflective optics eliminates chromatic errors and helps make it possible to operate over the broad wavelength range. To make the video camera sensitive to wavelengths below 400 nm, its cover windows are removed and the charge-coupled device is covered by a material that fluoresces visibly under ultraviolet light. In addition to making the image visible when testing with ultraviolet light, the video camera reduces the technician's strain by making it unnecessary to peer through a microscope. Furthermore, because the instrument is enclosed, it can be operated in a lighted room.

This work was done by Lawrence J. Steimle of Caltech for **NASA's Jet Propulsion Laboratory.**
NPO-18249/TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Ames Research Center, Moffett Field, California

Licensing Opportunity

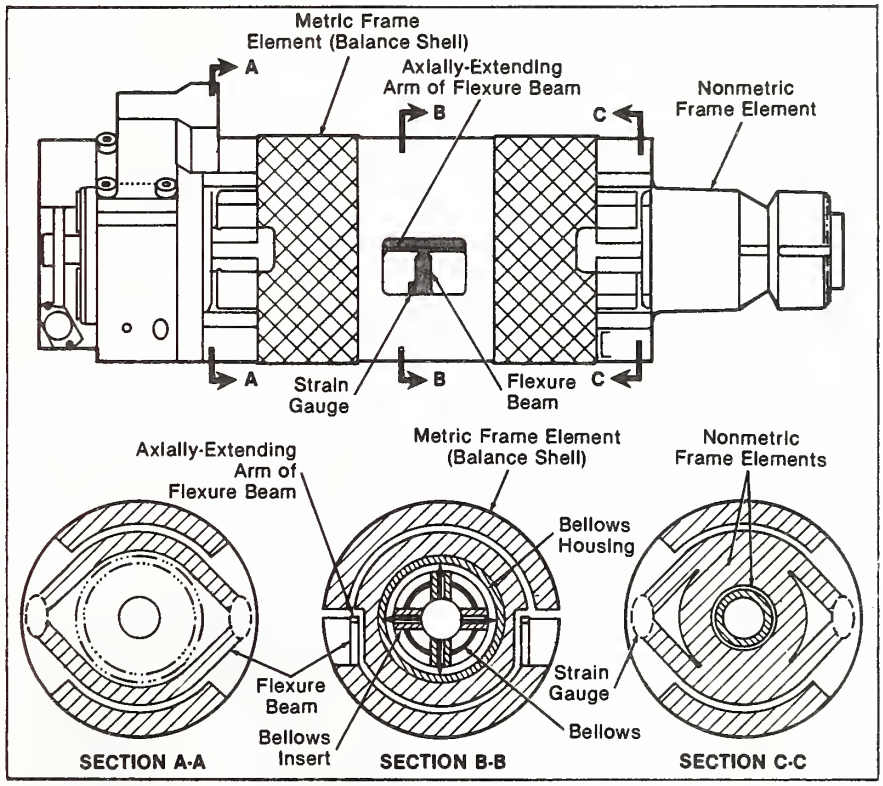
Low-Hysteresis Flow-Through Wind-Tunnel Balance

Symmetrical forces caused by internal flow are cancelled.

An improved flow-through wind-tunnel balance (see figure), which is less subject to hysteresis and spurious force readings than prior devices of this type, has been designed, fabricated, and tested. A wind-tunnel balance serves to mount a model aircraft on a sting in a wind tunnel and to measure the forces exerted on the model by the wind-tunnel flow. Compressed air or another pressurized fluid is fed from a passage in the sting through the internal passages of a flow-through wind-tunnel balance to supply power to the model. The improved flow-through wind-tunnel balance is designed to minimize the antisymmetrical spurious forces caused by the internal flow and to provide for measurement and correction of what little spurious forces remain.

A typical wind-tunnel balance of prior design includes a metric portion, to which the model is attached; a nonmetric portion, which is attached to the sting; and a metric break, which connects the metric and nonmetric portions. In this balance, frame elements of the nonmetric and metric portions and a set of flexure beams that connect them are all made together in one piece by electrical-discharge machining. In prior balances, mechanical hysteresis has arisen in part because these parts were made as separate pieces that were fastened mechanically and, therefore, could move with respect to each other. The one-piece construction of the metric break in this balance eliminates hysteresis for most practical purposes.

The pressurized fluid enters the balance along the common axis of the balance and the hollow sting. A bellows assembly seals those unpressurized passages surrounding the metric break from pressurized flows because they would produce undesired forces on the balance and model. Radial holes in a set of bellows inserts directs the flows to the pressurized passages across the metric break in a symmetrical manner that, in principle, produces zero net force in any direction. Thereafter, the flow is directed through other passages through the metric portion and into the model. Strain gauges measure the forces on the model by measuring the deflections of the flexure beams, and are so positioned on the flexure beams that the symmetrical forces caused by the internal flow result in zero net force readings.



The **Improved Flow-Through Wind-Tunnel Balance** includes features that minimize both spurious force readings caused by the internal pressurized flow and mechanical hysteresis.

To the degree to which residual effects of temperature, pressure, and internal flow give rise to spurious asymmetrical forces and force readings, it is desirable to correct for them. For this purpose, a pressure sensor and a temperature sensor are placed in one of the internal flow passages, and their outputs are fed to a data-reduction program for processing that corrects the strain-gauge force readings.

This work was done by N. Kunz, P.M. Luna, A.C. Roberts, and R.C. Smith of **Ames Research Center** *and W.L. Horne and K.M. Smith of Micro Craft, Inc.*

This invention has been patented by NASA (U.S. Patent No. 4,845,993). Inquiries concerning nonexclusive or exclusive licence for its commercial development should be addressed to the Patent Counsel, Ames Research Center. Refer to ARC-11877/TN.

Ames Research Ctr.
Technology Utilization Officer: Geoffrey S. Lee
Mail Code 223-3
Moffett Field, CA 94035
(415) 604-4044
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

NASA Tech Brief
National Aeronautics and Space Administration
Ames Research Center, Moffett Field, California

Licensing Opportunity

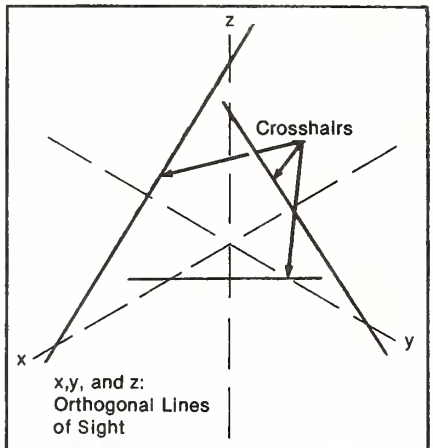
Multiple-Axis Crosshairs

Three skewed lines provide alignment when viewed along each of three mutually orthogonal axes.

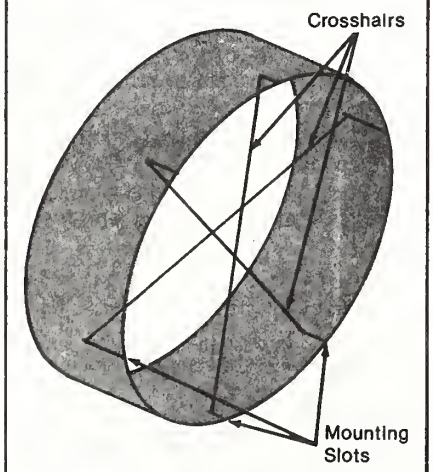
A multiple-axis crosshair device provides alignment when viewed along any of three mutually orthogonal axes. Because the device can be viewed in either direction along a given axis, it provides for viewing from any of six directions perpendicular to the faces of a cube. Unlike in many previous devices, the location of the common or target point can be "empty;" that is, no part of any crosshair has to pass through the target point.

In one version of the multiple-axis crosshair device (see left side of figure), a straight wire placed near (but not at) the origin of the axes in the *yz* plane, and at an angle of 45° to both the *y* and *z* axes serves as a crosshair in the *z* direction when viewed in either direction along the *y* axis or as a crosshair in the *y* direction when viewed along the *z* axis, thus locating the *yz* plane. Similarly, a wire placed analogously in the *xz* plane serves as a crosshair in the *x* and *z* directions and locates the *xz* plane, while a wire placed analogously in the *xy* plane serves as a crosshair in the *x* and *y* directions and locates the *xy* plane. Because there is no requirement that any of the three wires pass through the origin (the target point) or any other point, the mounting of the three wires is not complicated by mechanical interference among them.

In addition to being simpler and more compact than previous sets of crosshairs with similar capabilities have been, this device is more accurate and reliable because the same wire defines the same plane from two different directions. Moreover, because the target point can be "empty," a pentaprism can be placed there to serve as a convenient means of establishing orthogonal lines of sight through the target point. In one form, in which the three wires are all parallel to a common plane, a mount for the three wires can be made from a short cylinder with six short slots equally spaced around one end (see right side of figure); no part of the mount obstructs the six possible lines of sight.



TYPICAL CROSSHAIR CONFIGURATION ILLUSTRATING PRINCIPLE OF OPERATION



EXAMPLE OF CROSSHAIRS IN CYLINDRICAL MOUNT

A **Set of Multiple-Axis Crosshairs** typically consists of three skewed straight hairs or wires (left), which can be mounted on a short cylinder (right).

This work was done by Chris Barns of **Ames Research Center** *and William Gunter, Jr., of Photon Applications.*

This invention has been patented by NASA (U.S. Patent No. 4,957,357). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center. Refer to ARC-11886/TN.

Ames Research Ctr.
Technology Utilization Officer: Geoffrey S. Lee
Mail Code 223-3
Moffett Field, CA 94035
(415) 604-4044
Patent Counsel:
Darrell G. Brekke
Mail Code 200-11
Moffett Field, CA 94035
(415) 604-5104

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center, Houston, Texas

Specimen Holder for Flammability Tests

A frame and clamps are designed to minimize local overstress on the specimen.

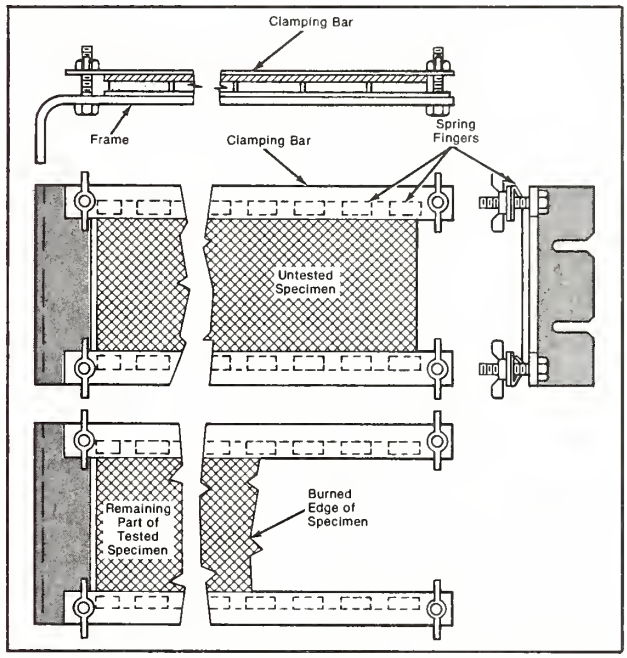
A fixture holds sheet specimens for flammability tests. It applies a nearly uniform local clamping pressure around the edges but accommodates changes in thickness caused by heating, without tearing or breaking the specimen. It accepts films, fabrics, foams, and other sheets, rigid or flexible. The specimens may be thin or thick, or of variable thickness. The heat capacity of the fixture is relatively low in comparison with that of prior, bulkier fixtures made for the same purpose: consequently, the new fixture interferes less with the interpretation of results of a test by drawing less heat away from the specimen.

The fixture includes a frame that has two parallel arms, a U-shaped holder, two strips of spring material segmented into finger springs, two clamping bars, bolts and wingnuts. The parts are made of stainless steel except for the spring clamps, which are made of beryllium copper because of its spring properties and its resistance to fatigue and flames.

A sheet specimen is placed on the arms of the holder, and a spring-clamp strip is laid over the specimen on each arm. Then a clamping bar is laid over each spring-clamp strip and bolted in place (see figure). Flammability testing can then proceed.

As the specimen burns, the spring fingers in contact with the remaining portion of the specimen continue to hold the specimen. If the specimen shrinks or swells in thickness, the fingers remain spring-loaded against the specimen, continuing to hold it with nearly constant force. Because they maintain contact along only a thin line, they conduct little heat from the specimen.

The frame could be designed to hold specimens of a variety of shapes and sizes. It could be bent to accommodate curved rigid specimens. It could also be used for such other tests as particle-impact tests.



Independent Spring Fingers hold the specimen on the arms of the frame.

This work was done by Michelle A. Rucker of **Johnson Space Center.** *MSC-21798/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Environmental Science & Technology

0505 New Technique for Assessing Groundwater Quality

Department of Energy

Technology Application

Lawrence Berkeley Laboratory

New Technique for Assessing Groundwater Quality

Information that is vital for assessing groundwater quality and supply, or cleaning up sites contaminated with toxic waste can be obtained faster, cheaper, and more accurately than ever before with a new technique from the Lawrence Berkeley Laboratory. Called "hydrophysical logging," this new technique is based on measuring the electrical conductivity of water in boreholes.

To measure groundwater quality and the hydraulic properties of fractures, a hole maybe 14 centimeters in diameter is bored into an aquifer. A television camera is then sent down to map the fractures that intersect the borehole walls. The problem is that a camera makes no distinction between the few fractures that actually conduct water and the majority that do not. Boreholes can be "packered" at various intervals to isolate sections of the borehole for detailed study and to collect water for chemical analysis. However, this is a costly procedure that still does not identify which specific fractures are contributing the water if the section contains more than one.

Enter hydrophysical logging. First a borehole is filled with deionized (electrically neutral) water. As this water is slowly pumped out, groundwater from fractures is drawn into the borehole, mixing with and displacing the deionized water.

The electrical conductivity of the water coming into the borehole from a specific fracture will be different from that of the deionized water and or any other fracture because of its unique chemical content.

Continually recording or "logging" the electrical conductivity changes taking place along the depth of the borehole as deionized water is displaced by groundwater reveals the location and flow rate of all the groundwater entering the borehole. The water's electrical conductivity can also be used to determine its chemical content.

This helps us to identify a contamination, determine its size, and trace it back to its origin. Once the source of contamination and its hydrologic environment have been identified, steps can be taken to clean it or isolate it from the aquifer.

With the help of a special computer program, "BORE," hydrologic logging can gather and analyze data ten times faster than the packer tests now in use, at a much lower cost. This should make it especially useful for municipal water supply studies, groundwater management and protection studies, contaminated site and remedial investigation studies, and any other situation where on-site evaluations are critical. Hydrologic logging can also provide the data needed to predict the destination over the next 10,000 years of buried radioactive wastes.

FOR ADDITIONAL INFORMATION: Public Information Department, ATTN: Lynn Yarris, Lawrence Berkeley Laboratory, Berkeley, CA 94720; Telephone (415)486-5375.

Manufacturing, Machinery & Tools

0506 Laser Drill Cell

0507 Cryogenic Cooling Improves Machine Tool Life

0508 Best Practices Library

0509 Methodologies For Product Integrity

0510 MSI Cell Emulation

0511 Technique Directly Deposits Copper Circuits onto Teflon

Testing & Instrumentation

0512 Increased Accuracy for CMM Probes

0513 Computer Program Aids Design of Impeller Blades—An iterative algorithm yields hydrodynamically optimal contours.

0514 Hybrid Hydrostatic/Transient Roller Bearing Assembly—The rolling-element bearing would be centrifugally unloaded at high speed. (Licensing Opportunity)

0515 Steel Collet for Welding Electrodes—A simple holder resists deformation and ensures reliable arc starting. (Licensing Opportunity)

Other Items of Interest

0490 Concurrent Engineering Handbook Available on Hypercard

0518 Metal Matrix Composite Vendor/Supplier Fabrication Evaluation

FOCUS:
METALS

TECHNOLOGY TRANSFER BULLETIN

AIR FORCE INDUSTRIAL BASE

Reference Number: MT92004M-FEB

Laser Drill Cell

General Electric Aircraft Engine (GEAE) Company

This Industrial Modernization Incentives Program (IMIP) project was implemented at the GEAE Madisonville Kentucky facility.

PROJECT PURPOSE

The high volume nature of airfoil production at Madisonville, Kentucky, coupled with broad impact on military hardware, made this project one of the first IMIP projects at GE. This project addressed the need for increased process control and repeatability in the laser drilling process. Elements of improving control, and reducing the labor input, include features such as automated wax injection. The challenge of this project was to link the major process technologies together into an integrated production cell.

APPROACH

The laser drilling cell consists of automation of the following steps in the production process: encapsulation of blades and vanes for fixturing wax injection (to protect the part from "scarfing" when a hole is overdrilled); wax removal; inspection; deburring; part movement and handling; and part tracking. Computer integration provides part tracking and routing, fault monitoring and other coordination. An overdrill/underdrill prevention system will reduce scrap and rework. Greater throughput, higher yields, and significant cost savings are being achieved.

PROJECT BENEFITS

The principal systems benefiting from this IMIP project are the F101, F110 and F404 engines. The successful implementation of the Laser Drill Cell provided the following benefits:

(Project Benefits continued)

- automated operations
- significantly increased throughput
- improved quality
- reduced manufacturing losses
- reduced cycle time and in-process inventory
- real-time scheduling and control

APPLICATIONS

This project applies to the laser drilling of cooling holes in jet engine airfoils.

LESSONS LEARNED

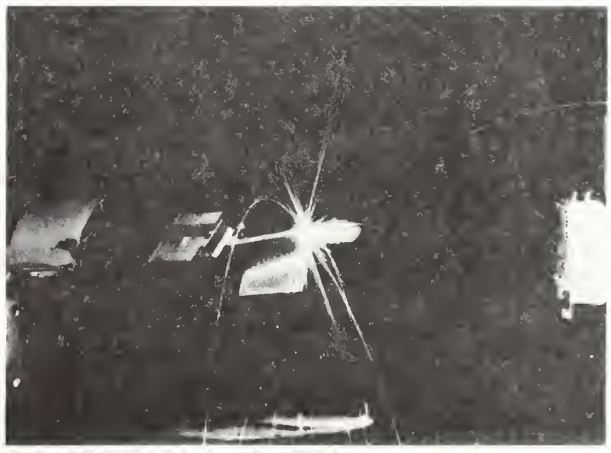
Modular development of individual technologies (laser drill, wax injection, wax removal, inspection, and material management) simplified the implementation of a complex system.

PROJECT STATUS

Implementation of the laser drill cell is complete.

TECHNICAL DOCUMENTATION

Defense Technical Information Center (DTIC) reference number: AD-B107716



Continued on reverse side

GOVERNMENT SPONSOR

Aeronautical Systems Division
ASD/YZD (Melissa Gregory)
Wright-Patterson AFB, OH 45433-6503
(513) 255-2244

COMPANY POINT-OF-CONTACT

General Electric Aircraft Engine (GEAE) Company
Mr. Ted Ham
Mail Stop A328
1 Neuman Way
Cincinnati, OH 45215-6301
(513) 774-3738

INDUSTRIAL TECHNOLOGY OMBUDSMAN

Wright Laboratory
WL/MTX (Robert Reifenberg)
Wright-Patterson AFB, OH 45433-6523
(513) 255-7362

APPROVED FOR PUBLIC RELEASE

The purpose of the **Technology Transfer Bulletin** is primarily to highlight successful or promising applications of industrial technologies with proven or probable worth to industry and the Air Force. It also provides a vehicle for airing initiatives within the Air Force Industrial Base Program. This document provides an awareness of these technologies and initiatives to foster interaction between industry and the Government to benefit the defense industrial base. All comments concerning this document should be addressed to WL/MTX (Industrial Technology Ombudsman) Wright-Patterson AFB, OH 45433-6523.

The **Technology Transfer Bulletin** does not imply any endorsement or commitment by the Government to procure given technology, process, or product.

FOREIGN DISSEMINATION

Details regarding many manufacturing technology programs (for example: MANTECH and IMIP) are subject to special export controls. Therefore, follow-up from any foreign source should be processed through embassy channels following normal procedures for request of technical information or technology transfer.

Cryogenic Cooling Improves Machine Tool Life

Efforts to increase machine tool productivity with high pressure cryogenic cooling are coming to completion, and the results look promising. The Air Force's contractor, the Institute for Advanced Manufacturing Sciences (IAMS), is conducting its final series of integration tests using a flowjet system, with the mechanical and control systems of a computer numerically controlled lathe. Results of the program were presented to both industry and Government on 14 January 1992 at the IAMS Technical Center in Cincinnati, Ohio.

The objective of this two and one half-year program was to validate a new high pressure cryogenic coolant flow delivery system on a working production line machining weapon system components. Benefits included improved surface finish and tool life by a factor of 2 to 9, increased metal removal rate by 200 percent, and unattended chip control. The actual program has evaluated the machining of numerous metals, including aluminum and titanium alloys. Wear curves have been plotted for the completed testing, and tool life extensions are clearly shown. Additionally, a matrix of conditions varying the lathe's turning speed and feed rate were run to compare built-up edge, surface finish, and chip form. Initial results showed less built-up edge and more manageable chips, but slightly rougher surface finish. Results of all testing will be analyzed and incorporated into a "Technology Value Analysis," showing potential savings and returns.

FOR ADDITIONAL INFORMATION: To discuss this effort further, contact: Project Engineer: Siamack Mazdiyasni, Air Force Manufacturing Technology Program, ATTN: AFWAL/WL/MTPM, Wright Patterson AFB, OH 45433-6533; (513)255-3612. Refer to contract: F33615-89-C-5730.

NAVY Manufacturing Technology Program

Best Practices Library

The Best Manufacturing Practices Program continues to expand resources available to industry by establishing a Best Practice Video Library. Several companies have produced videos of their best practices and have offered to share them through the BMP program. The video subjects are not limited to BMP documented practices and will be made available on a loan basis through the BMP program's West Coast office. If a video proves to be popular, copies can be made at the borrower's expense after obtaining permission from the company that originally produced the video.

All companies are invited and encouraged to send videos to the West Coast Office for inclusion in the BMP video library. The office needs one copy of each video in VHS format. For additional information contact:

Amy Scanlan
West Coast Representative
U. S. Navy BMP Program
1033 Mountain Drive
Oak Harbor, WA 98277
(206) 675-0620

NAVY Manufacturing Technology Program

Methodologies For Product Integrity

Producibility Measurement Guidelines, Methodologies for Product Integrity has been drafted as a follow-on to the handbook, Producibility Measurement for DOD Contracts - Or How Can I Make What the Government Wants Without Losing My Shirt?. This document describes and details two tools for government and contractor personnel to conduct quantifiable producibility measurement, and presents a model roadmap for producibility program implementation and management. The information presented in this document has been successfully applied by leading U.S. corporations and is supported by current industry practices exemplified in the case studies.

This document is a reference tool for anyone involved in determining an organization's ability to design and manufacture a quality product. Consequently, it should be used throughout the production process by people such as program managers, design engineers, or manufacturing engineers. It should also be used by those who make producibility measurements, manage a producibility program, or participate in the process.

Copies of the final draft can be obtained from:

Roy Witt
GE Aerospace
1235 Jefferson Davis Highway
Suite 409
Arlington, VA 22202
FAX (703) 892-3245.

MSI Cell Emulation

A new NIST emulation system is a versatile tool for configuring machining cells for efficient production. The system produces operating data for various configurations that can be used to choose the best method, before hardware is purchased or without actually running existing hardware.

The cell emulation system is part of the Manufacturing Systems Integration Project (MSI) testbed. The testbed allows experimentation with new production management and control system approaches. Results of testbed activities also provide input to international standards through NIST's participation in International Standards Organization committees.

The emulation system mimics the behavior of an actual machining cell. It can respond to commands, execute process plans, consume resources, generate data, break down due to errors, and exhibit non-deterministic behavior. It consists of several computers connected to a cell controller via a communications network. Each computer emulates a single controller or other manufacturing device. The cell controller is in turn connected to other testbed factory systems such as a scheduling system, a database system, and a tool management system. Graphics screens and statistical summary screens are used to demonstrate system behavior.

The MSI testbed supports both real and emulated shop floor equipment. This intermixing of systems is accomplished by means of well-defined interfaces and protocols between the various manufacturing systems. These interface definitions are a major part of the MSI architecture specification.

During the past two years the MSI project has identified and addressed integration issues that limit the ability to integrate production planning, scheduling, and shop control systems. This effort has produced a reference architecture for the integration of software based applications that support planning, scheduling, and control of mechanical parts production.

FOR ADDITIONAL INFORMATION: To discuss this effort further, contact: Linda Wood, Building 222, Room B212, AMRF Project, National Institute of Standards and Technology, Gaithersburg, MD 20899; (301)975-3417.

Sandia National Laboratory

Technique Directly Deposits Copper Circuits onto Teflon

A technique for directly depositing copper circuit lines on Teflon has been developed by researchers at Sandia National Laboratories and the University of New Mexico.

The technique is much simpler than the currently used process, which requires at least eight steps. It may prove important for achieving high-frequency operations in computer, communications, and radar applications.

A number of companies have already shown early interest in the new process, and several industrial groups have made visits, the researchers say.

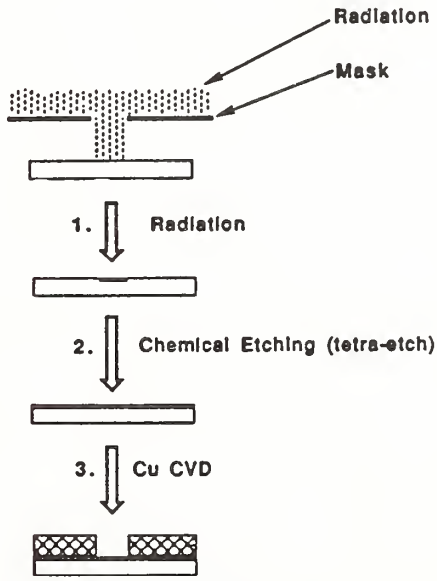
For many electronic needs the ideal combination is copper conductors on (poly) tetrafluoroethylene (PTFE) substrates. PTFE is better known by the DuPont trade name of Teflon. The copper has high electrical conductivity and is used to conduct electrical current. Teflon is an excellent insulator with an extremely low dielectric constant, among the lowest of all common materials. This low dielectric constant makes for low capacitance coupling—essentially low electrical interference—between circuit lines placed on it.

With lower electrical interference, circuits can be placed closer together and operated faster, allowing for smaller devices, or operation at higher frequencies, or both.

Needed for high-frequency circuits

The need for such a low dielectric material is becoming increasingly important for computers, communications, and radar as the limits of high frequency operation are advanced. Printed wiring boards consisting of copper conducting lines on Teflon substrates are commonly used in advanced high-frequency radars, for example. But making these circuit boards is difficult. The well-known physical and chemical inertness of Teflon that makes it good for nonstick frying pans also makes bonding copper circuit material to it a challenge.

Printed wiring boards are now made by bonding copper to the Teflon by mechanical rolling, a process that leads to formation of a thick copper film. The film is subsequently patterned into electronic circuits using a series of standard photoresist processes whereby the unwanted material is chemically removed. This process involves at least eight steps. Furthermore, with such thick films it is difficult to produce narrow, submicrometer-dimension line patterns—from a microscopic viewpoint one would essentially have to create great towers of copper.



Schematic representation of patterned deposition of copper on PTFE. Just three steps, all additive, are required.

The Sandia and University of New Mexico researchers have developed a method for the direct formation of patterned copper films on Teflon. It involves only three steps and is an additive process—there are no subtractive steps in which unwanted material must be removed. The copper films can be made as thin as desired.

The researchers are Robert R. Rye, a Sandia chemist; Mark J. Hampden-Smith, a UNM inorganic chemist; and Toivo T. Kodas, a UNM chemical engineer.

In the first step, the part of the Teflon surface where no copper is wanted is irradiated with x-rays or electrons. If x-rays are used, a suitable line-of-sight mask keeps the x-rays from striking areas of the desired circuit path. If electrons are used, the same technology as used in a television tube can be used to directly write a pattern on the surface.

In step two, the entire Teflon sample is then subjected to a commercial chemical etching solution. The researchers discovered that only those areas that have not been irradiated are appreciably altered; the irradiated areas remain unaltered. (Rye believes this is apparently because the irradiation causes the surface molecules of Teflon to cross-link, making them impervious to the etching.)

Step three involves chemical vapor deposition (CVD) of copper onto the Teflon surface. The researchers found that the copper deposits only on the areas that were etched—and those are the areas that were not irradiated. This selective deposition creates the desired pattern.

Step three is more general. Sandia researchers (Rye and Antonio Ricco) have very recently demonstrated this step with electroless copper deposition, an industry standard technique for copper plating. This is a well-known solution technique everyone is familiar with. It's done at room temperature with simple equipment.

The researchers emphasize that the patterned deposition of copper is solely a consequence of the initial patterned irradiation; the entire sample is subjected to the subsequent chemical etching and copper CVD steps.

The result is an additive process in which copper is deposited in three steps preferentially on those regions of the Teflon surface that have not been initially irradiated.

'Immense advantages'

"This process has immense advantages over earlier techniques," says Rye. "It involves only three steps instead of about eight, and it can do it better. It can make thinner circuit lines and make them closer together."

A joint Sandia-UNM patent of the process for patterned deposition of copper on poly (tetrafluorethylene) was filed on September 30. (An earlier patent has already been allowed on Rye's work on the patterning of Teflon itself.)

Rye, Hampden-Smith, Kodas, and UNM researcher K.-M. Chi have submitted a paper to *Applied Physics Letters.*

The researchers made their first report to a conference on Advanced Metallization for ULSI Applications, October 8–10, 1991, Murray Hill, New Jersey. They also presented a paper at the Fall meeting of the Materials Research Society, December 2–6, in Boston.

Rye says a number of companies have already expressed interest in the process. Information exchange is under way and possible technology transfers are under discussion. "It's creating quite a stir," says Rye.

Although the initial uses would appear to be in making printed circuit boards, where the copper strips are used to connect a variety of microelectronic devices, the technique may also have applications in the microelectronic devices themselves. Sandia's own Microelectronics Development Laboratory (MDL) is already exploring copper interconnects as wiring for next-generation computer chips, as part of an advanced manufacturing initiative program for the Department of Energy.

In concert with the printed circuit board applications, Bob Blewer and Tom Omstead have joined with Rye and the UNM researchers to seek DOE funding for demonstrating the use of chemical-vapor-deposited copper with a "spin-on" form of Teflon, which would make the technology appropriate for improved-performance computer chips. Blewer, head of the division that is responsible for advanced metallization development at the MDL, said Omstead and Jim Fleming have confirmed that spin-on Teflon films can be applied with acceptable adhesion and uniformity. "If this form of Teflon responds as well as the bulk Teflon to irradiation patterning and copper deposition, a very high speed interconnection technology may be in the offing."

Two research lines converged

Discovery of the new process resulted from a convergence in 1991 of two lines of research. At Sandia, Rye had found and reported that irradiation of Teflon could be used for patterned etching and adhesion. At UNM, Hampden-Smith and Kodas were finding that chemical vapor deposition of copper could be accomplished selectively on a variety of surfaces using a series of new metal-organic compounds. Combining the two insights makes the patterned deposition possible. "Everything just came together perfectly," says Rye.

FOR ADDITIONAL INFORMATION: Technical Contacts: Robert R. Rye (505)844-9194; Mark Hampden-Smith, UNM (505)277-4713; and Toivo T. Kodas, UNM (505)277-4030, Department of Energy, Sandia National Laboratories, Albuquerque, NM 87185-5800.

Navy Manufacturing Technology

Automated Manufacturing Research Facility

National Institute of Standards & Technology
U.S. Department of Commerce, Gaithersburg, MD 20899

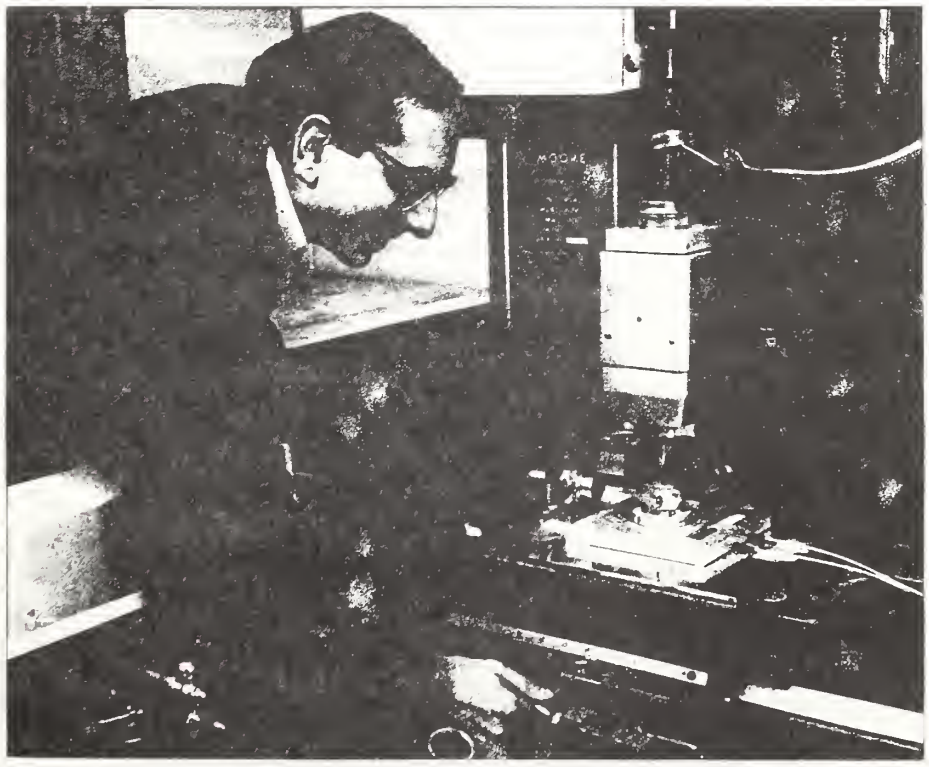
Increased Accuracy for CMM Probes

Engineers at NIST have developed an error correction method for analog probes used with Coordinate Measuring Machines (CMM). The method is easy to implement and can improve the accuracy of probe measurements by as much as a factor of thirty.

A CMM is used to measure the three-dimensional shape and size of manufactured parts using a probe as its touch sensor. The two principal types of contact probes used are touch-trigger and analog probes. Analog probes, when their performance is carefully characterized, yield better measurements than touch trigger probes.

Analog probes are really miniature measuring machines - they provide an analog signal proportional to the displacement of the probe stylus. Analog probes are used with CMM of the highest measurement accuracy, and for an operation called "scanning" in which the probe is swept over a part with complicated geometry (eg. a gear, bearing assembly, or turbine blade) to obtain high-density information about the geometry of that part.

The new metrology system developed at NIST is called MiniMeas. MiniMeas is used to characterize analog probes at the 0.1 micrometer level. Using MiniMeas, the probe stylus is moved along a known path and its output is recorded, simulating the measurement of an object. The probe stylus can be positioned with an accuracy of ± 0.05 micrometers by using a co-planar flexure stage and laser interferometers under computer control. Systematic errors can be corrected using software error compensation once the measurement accuracy of



MiniMeas Metrology System

the probe has been determined.

The measurement of systematic probe errors can be used either to improve probe manufacturing, or as a basis for software error correction of data gathered from CMM measurements.

FOR ADDITIONAL INFORMATION: To discuss this effort further, contact: Howard Harary, Building 220, Room A107, AMRF Project, National Institute of Standards and Technology, Gaithersburg, MD 20899; (301)975-3485.

NASA Tech Brief
National Aeronautics and
Space Administration
Marshall Space Flight Center, Alabama

Computer Program Aids Design of Impeller Blades

An iterative algorithm yields hydrodynamically optimal contours.

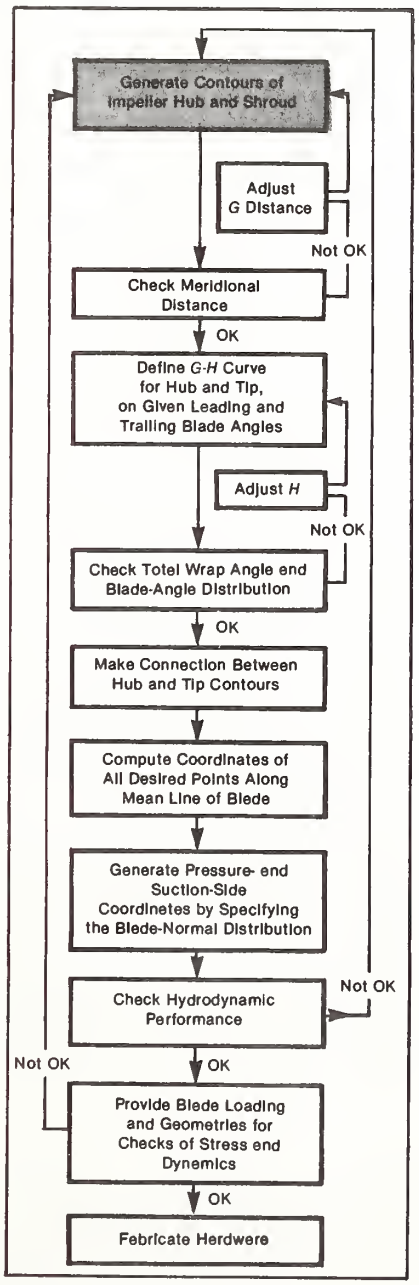
Impeller blades for centrifugal turbopumps can be designed quickly with the help of a computer program. The program lays out a blade in the *G–H* plane; this ensures a smooth blade-angle distribution because the slope of a *G–H* curve is the blade angle. (*G* is the meridional distance, and *H* is the circumferential distance in a plane perpendicular to the axis of rotation.)

The program (see figure) is written so that the contour of the blade between the hub and the tip of the impeller is described by a polynomial. This not only guarantees tangency of the contour at the inlet and outlet but also guarantees a smooth transition from the inlet to the outlet.

With the program, an engineer can check the smoothness of the blade angle and the total wrap angle. The engineer can also take advantage of the fact that there exists a range of *H* for which the hub and tip have about the same total wrap angle — a condition that enhances the performance of the impeller.

Because the program defines blade geometries algebraically, digitized and graphical approximations are avoided. Moreover, the program can be executed rapidly, so that an engineer can review many alternatives at relatively low cost before selecting a final design. Although the program was written for centrifugal turbomachinery, it can readily be adapted to such axial pump components as inducer blades and stator vanes.

This work was done by Wei-Chung Chen and John V. Galazin of Rockwell International Corp. for **Marshall Space Flight Center.** *MFS-29783/TN*


Generate Contours of Impeller Hub and Shroud
Adjust G Distance
Not OK
Check Meridional Distance
OK
Define G-H Curve for Hub and Tip, on Given Leading and Trailing Blade Angles
Adjust H
Not OK
Check Totel Wrap Angle end Blade-Angle Distribution
OK
Make Connection Between Hub and Tip Contours
Compute Coordinates of All Desired Points Along Mean Line of Blede
Generate Pressure- end Suction-Side Coordinetes by Specifying the Blede-Normal Distribution
Check Hydrodynamic Performance
Not OK
Not OK
OK
Provide Blede Loading and Geometries for Checks of Stress end Dynemics
OK
Febricate Herdwere

A Program Generates Blade Contours and continually subjects them to evaluation. It checks the physical parameters to ensure that they are compatible with the required performance and recycles a design if criteria are not met.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Licensing Opportunity

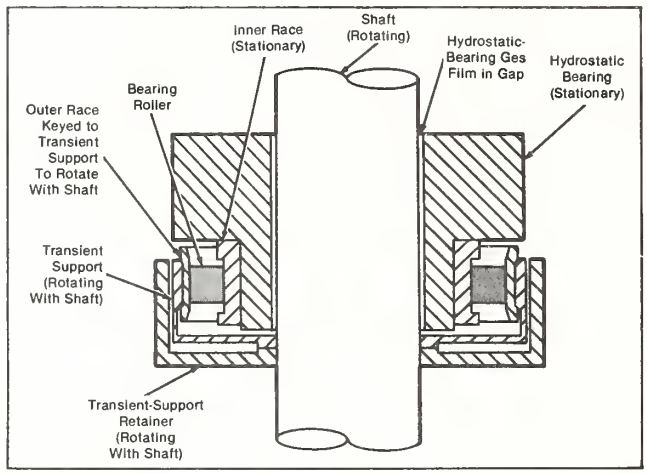
Hybrid Hydrostatic/Transient Roller Bearing Assembly

The rolling-element bearing would be centrifugally unloaded at high speed.

A proposed bearing assembly for the shaft of a high-speed turbopump would include both hydrostatic and rolling-element bearings. As in other hybrid hydrostatic/rolling-element bearing assemblies, the rolling elements would support the shaft during relatively slow rotation at startup and shutdown, when the pump pressure is too low to provide a sufficiently stiff hydrostatic gas-film bearing. The proposed bearing assembly would differ from prior assemblies of this type in the manner of interaction between the rolling-element and hydrostatic bearings.

The bearing assembly (see figure) would include a stationary journal bearing that would serve as the hydrostatic bearing: the hydrostatic-bearing gas film would be formed by designed leakage of the pressurized pumped gas along the gap between the shaft and the radially inner surface of this bearing. The inner race of the rolling-element bearing would be mounted on a radially outer surface of the hydrostatic bearing. The outer race of the rolling-element bearing would be keyed to a support (called the "transient" support because it would carry the load during the startup and shutdown transients) attached to the shaft so that both would rotate with the shaft. (Relative rotation between the transient support and the outer race must be prevented, especially if the pumped fluid is liquid oxygen, in which a high-speed rub could produce catastrophic results.)

At speeds of rotation great enough to generate a hydrostatic bearing that radially supports the shaft, centrifugal force would be great enough to expand the outer race and transient support so much that the bearing rollers would cease to be in contact with the inner race; that is, the rolling-element bearing would stop carrying the radial load. A transient-support retainer, also rotating with the shaft, would prevent excessive centrifugal outward expansion of the transient support. The transient-support retainer would also transmit a fractional load to the rolling-element bearing, if necessary, in the event that the shaft makes an excessive radial excursion (for example, if the pump is shaken hard sideways).


Inner Race (Stationary)
Shaft (Rotating)
Hydrostatic-Bearing Ges Film in Gap
Hydrostatic Bearing (Stationary)
Bearing Roller
Outer Race Keyed to Transient Support To Rotate With Shaft
Transient Support (Rotating With Shaft)
Transient-Support Retainer (Rotating With Shaft)

The **Rolling-Element Bearing** would be unloaded at high speed by centrifugal expansion of the outer race and transient retainer.

This work was done by John F. Justak of United Technologies Corp. for **Marshall Space Flight Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center. Refer to MFS-28491/TN.

George C. Marshall Space Flight Center
Technology Utilization Officer: Ismail Akbay
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
Patent Counsel:
Robert L. Broad, Jr.
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0021

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

NASA Tech Brief
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama

Licensing Opportunity

Steel Collet for Welding Electrodes

A simple holder resists deformation and ensures reliable arc starting.

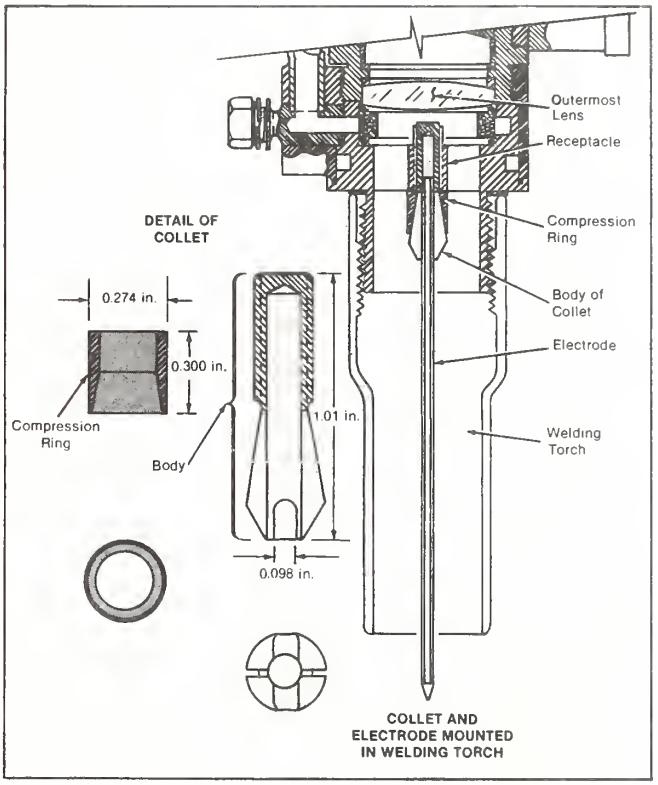
An improved steel collet holds an electrode for tungsten inert-gas welding but allows quick and easy replacement. It also ensures reliable arc starting.

The collet consists of a body with tapered and threaded sections and a compression ring (see figure). The electrode is inserted in a blind hole in the body. The ring is slipped onto the tapered section of the body. When the threaded end of the body is screwed into a receptacle in the welding torch, the ring compresses the body so that it clamps the electrode. The assembly can be removed from the torch simply by unscrewing the body.

The steel collet replaces a copper collet that had several deficiencies, one of which was that starting an arc usually required several attempts. The tool steel and stainless steel used in the new collet have thermal conductivities lower than that of copper; this promotes the emission of electrons and makes starting easier. With the new collet, as a result, an arc always starts on the first attempt. Moreover, the steels are not as vulnerable to galling and deformation as copper is.

The installation and removal of the electrode were more difficult with the old collet. The technician had to turn a nut on a left-handed thread on the collet to clamp the electrode, then screw the right-handed thread on the end of the collet into the torch. Now, only one threading operation is needed.

In the old collet, the electrode was held in a through hole. The new collet holds it in a blind hole. Thus, the inner end of the electrode cannot slip through the collet and damage the lenses in a coaxial-vision torch.



The **Slip-On Compression Ring** compresses the tapered section of the body of the collet around the inner end of the welding electrode. The collet is mounted in a receptacle below a stack of lenses and filters in a coaxial-vision welding torch. The blind hole in the collet protects the outermost lens from damage by the electrode.

This work was done by Jeffrey L. Gilbert, David A. Gutow, Richard K. Burley, and Irving Fogul of Rockwell International Corp. for **Marshall Space Flight Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center. Refer to MFS-29762/TN.

George C. Marshall Space Flight Center
Technology Utilization Officer: Ismail Akbay
Code AT01
Marshall Space Flight Center,
AL 35812
(205) 544-2223
Patent Counsel:
Robert L. Broad, Jr.
Mail Code CC01
Marshall Space Flight Center,
AL 35812
(205) 544-0021

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Materials

0516 Accelerated Cooled/Direct Quenched (AC/DQ) Steels

0517 Integrated Composites Center (ICC)

0518 Metal Matrix Composite Vendor/Supplier Fabrication Evaluation

0519 Mullite Whiskers and Mullite-Whisker Felt Produced

0520 Polymeric Electrolyte Containing 12-Crown-4 Ether—Ionic conductivity and charge-transfer efficiency are enhanced. (Licensing Opportunity)

Other Items of Interest

0511 Technique Directly Deposits Copper Circuits onto Teflon

0526 More Sensitive Analysis: X-Ray Microprobe/Microscope

Manufacturing Technology USAF

WRIGHT LABORATORY

FOCUS: METALS

TECHNOLOGY TRANSFER BULLETIN

AIR FORCE INDUSTRIAL BASE

Reference Number: MT92005M-FEB

Accelerated Cooled/Direct Quenched (AC/DQ) Steels

Bethlehem Steel Corporation - Bethlehem, PA
Lukens Steel Company/USS Joint Venture - Pittsburgh, PA

This project is being conducted under **Title III** of the Defense Production Act. Title III provides incentives to establish or expand domestic production capability for minerals, metals, and materials essential to the national defense.

PROJECT PURPOSE

The DOD has an increasing demand for high strength, tough, weldable steel plate for ship, submarine, and armored vehicle construction. The Title III objective is to reduce foreign dependency by providing purchase incentives to industry to create a domestic capacity for producing AC/DQ steel plate for the DOD.

APPROACH

To implement the Title III objective, the following time-phased results are expected:

- Provide 65, 80, and 100 KSI yield strength (Navy applications) and low-carbon rolled homogenous armor (RHA-Army applications) AC/DQ processed steel in thicknesses ranging from 1/2" to 3-3/4" for evaluation by potential users - almost 1,000 tons.
- Establish domestic capacity for AC/DQ steel plate in Phase II (to be competitively procured in FY 95).
- Establish second source if demand is sufficient in Phase III (to be competitively procured in FY 00).

PROJECT BENEFITS

Domestically produced AC/DQ steels will increase the national security capability by saving significant amounts of critical alloying elements, reducing costs of critical high strength plate production, reducing plate production and pre-weld/post weld heat treatment energy requirements, improving the ability to fabricate/weld the plates into usable products, improving the performance of high strength steels - thereby reducing vehicle weight, and providing a modern basis for further ferrous and non-ferrous alloy developments.

APPLICATIONS

The two principal expected applications for the DOD are naval vessels (e.g., CVN-71) and armored vehicles (e.g., M1-Abrams).

LESSONS LEARNED

Conclusions to date are as follows:

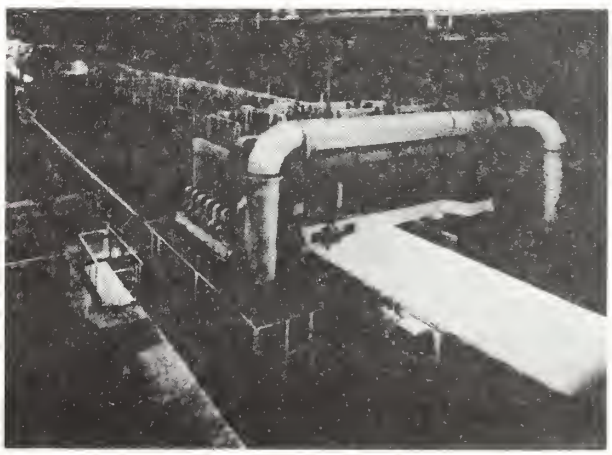
- lean alloying and low carbon levels shown to work with AC/DQ and controlled rolling.
- DQ provides better property balance than AC
- DQ must be followed by an extra step (tempering); AC self tempers.
- Cooperative technology transfer agreement effectively established between United States and Japanese steel industries.

PROJECT STATUS

Phase I, (Task I) production and qualification testing, was completed in December 1991. Phase II, production demonstration of qualified material, is currently projected for a 1993 start.

TECHNICAL DOCUMENTATION

For additional information contact one of the offices listed on the reverse side of this bulletin.



Continued on reverse side

GOVERNMENT SPONSOR

Navy, David Taylor Research Center -
Mr. Ed Hacket
Navy, Sea Systems Command - Mr. Charles Hull
Army, Materials Technology Laboratory -
Mr. Art Ayvasian

Project Manager: Mr. Phil Tydings
Wright Laboratory, Manufacturing Technology
Directorate (WL/MTD)
Wright-Patterson AFB, OH 45433-6523
(513) 255-9665 DSN: 785-9665

COMPANY POINT-OF-CONTACT

Bethlehem Steel Corporation - Dr. John Chilton
Steel Products Division, Homer Research Lab.
Bethlehem, PA 18016-7699
(215) 694-3320

Lukens/USS Joint Venture:

Lukens Steel Company, Mr. Alex Wilson
Research Center, ARC Building
Coatesville, PA 19320-5407
(215) 383-3105

USS Technical Center, Mr. Sam Manganello
Mail Stop A-11, Heavy Products
Monroeville, PA 15219-4776
(412) 825-2080

INDUSTRIAL TECHNOLOGY OMBUDSMAN

Wright Laboratory
WL/MTX (Robert Reifenberg)
Wright-Patterson AFB, OH 45433-6523
(513) 255-7362

APPROVED FOR PUBLIC RELEASE

The purpose of the **Technology Transfer Bulletin** is primarily to highlight successful or promising applications of industrial technologies with proven or probable worth to industry and the Air Force. It also provides a vehicle for airing initiatives within the Air Force Industrial Base Program. This document provides an awareness of these technologies and initiatives to foster interaction between industry and the Government to benefit the defense industrial base. All comments concerning this document should be addressed to WL/MTX (Industrial Technology Ombudsman) Wright-Patterson AFB, OH 45433-6523.

The **Technology Transfer Bulletin** does not imply any endorsement or commitment by the Government to procure given technology, process, or product.

FOREIGN DISSEMINATION

Details regarding many manufacturing technology programs (for example: MANTECH and IMIP) are subject to special export controls. Therefore, follow-up from any foreign source should be processed through embassy channels following normal procedures for request of technical information or technology transfer.

Manufacturing Technology USAF

WRIGHT LABORATORY

FOCUS: NONMETALS

TECHNOLOGY TRANSFER BULLETIN

AIR FORCE INDUSTRIAL BASE

Reference Number: MT92001NM-FEB

Integrated Composites Center (ICC)

McDonnell Aircraft Company

This project was conducted under the MANTECH program. As part of the Air Force Industrial Base Program, MANTECH provides new manufacturing techniques to solve production and design-to-production problems. McDonnell Aircraft Company implemented this project at St. Louis, Missouri.

PROJECT PURPOSE

The purpose of the ICC MANTECH project was to establish a site specific composite center that would demonstrate a significant reduction in production costs, while establishing a higher level of quality in both end-product and manufacturing performance.

APPROACH

Information management for the ICC was addressed at three levels: (1) the enterprise level, responsible for scheduling of the entire aircraft; (2) the process center level, responsible for managing process data, electronic work order display and data collection, labor and performance reporting, work center scheduling, work order management, product assurance, tool management, time sensitive material management, etc.; and (3) the shop-floor level, where the composite parts are manufactured.

Application software for all three levels was designed and implemented using a common database. Shop floor processes and equipment (e.g., automated packaging machine automated ply cutters, ply distribution center, automated core carver, abrasive water jet trimming system, robotic router, and quality interpretation center) were updated and refined. Arizona State University was the independent technology transfer agent for ICC producing an implementation guide, workshop and graduate-level manufacturing courses relative to ICC. An Industry Review Board assisted in making the ICC project a success.

PROJECT BENEFITS

- Manufacturing processes are monitored and controlled.
- Error free and timely information
- Disciplined systems and processes
- Quality built into the process
- Process both simplified and streamlined
- Enabler for pull scheduling, variability reduction, and activity based costing
- Decreases in touch and non-touch labor resulting in significant savings for the F-15, F-18, and AV8B programs.

APPLICATIONS

ICC technologies are best suited for the integration of fabrication/assembly manufacturing processes (emphasis concentrated on composites).

PROJECT STATUS

This MANTECH project was completed in February, 1990.

LESSONS LEARNED

The ICC system functions as a central information repository for information that, prior to its existence was not centralized.

Continued on reverse side

TECHNICAL DOCUMENTATION

The final technical reports have document numbers of AFWAL-TR-89-8027 (92 documents) and WRDC-TR-90-8006 (2 documents).

GOVERNMENT SPONSOR

Wright Laboratory
WL/MTPN (Mr. Paul Pirrung)
Wright-Patterson AFB, OH 45433-6523
(513) 255-7277

INDUSTRIAL TECHNOLOGY OMBUDSMAN

Wright Laboratory
WL/MTX (Robert Reifenberg)
Wright-Patterson AFB, OH 45433-6523
(513) 255-7362

COMPANY POINT-OF-CONTACT

McDonnell Aircraft Company
Mr. Keith O. Wiig
P.O. Box 516
St. Louis, Missouri 63166-0516

Independent Technology Transfer Agent:
Arizona State University
College of Engineering and Applied Sciences
Computer Integrated Manufacturing Systems
Research Center
Tempe, AZ 85287
Dr. Dan Shunk (602) 965-3709
Dr. Richard Smith (602) 965-3185

APPROVED FOR PUBLIC RELEASE

The purpose of the **Technology Transfer Bulletin** is primarily to highlight successful or promising applications of industrial technologies with proven or probable worth to industry and the Air Force. It also provides a vehicle for airing initiatives within the Air Force Industrial Base Program. This document provides an awareness of these technologies and initiatives to foster interaction between industry and the Government to benefit the defense industrial base. All comments concerning this document should be addressed to WL/MTX (Industrial Technology Ombudsman) Wright-Patterson AFB, OH 45433-6523.

The **Technology Transfer Bulletin** does not imply any endorsement or commitment by the Government to procure given technology, process, or product.

FOREIGN DISSEMINATION

Details regarding many manufacturing technology programs (for example: MANTECH and IMIP) are subject to special export controls. Therefore, follow-up from any foreign source should be processed through embassy channels following normal procedures for request of technical information or technology transfer.

Manufacturing Technology USAF

WRIGHT LABORATORY

FOCUS:
METALS

TECHNOLOGY TRANSFER BULLETIN

AIR FORCE INDUSTRIAL BASE

Reference Number: MT92014M - APR

Metal Matrix Composite Vendor/Supplier Fabrication Evaluation

This project was conducted under the MANTECH program. As a part of the Air Force Industrial Base Program, MANTECH provides new manufacturing techniques to solve production and design-to-production problems. This project was conducted at Textron Specialty Materials, at their facility in Lowell, Massachusetts.

PROJECT BACKGROUND/PURPOSE

Throughout the history of metal matrix composite fabrication, especially titanium matrix composite (TMC) fabrication, the inclination has been to manufacture one of a kind parts or test panels. The basic expense of raw materials and the extensive hands-on labor involved in the actual fabrication of one-of-a-kind TMC parts results in high acquisition costs. Usually, not enough parts and/or panels have been fabricated to truly analyze the potential for reduced labor and cost through standardized production quantities, methods and procedures. The two-fold goal of this program was (1) to demonstrate the benefits of fabricating production quantities of TMCs and (2) to provide the fabricated material to aerospace manufacturing vendors to assess their capability to conduct the necessary secondary processing to form finished composite parts. The complete results of these two activities will be documented to support the high temperature composites industrial base and to promote increased TMC utilization.

APPROACH

A total of 96 12"x12" flat panels using a carbon core silicon carbide (SCS-6) fiber and two different titanium matrix alloys were fabricated. The titanium matrices selected for fabrication were Ti-6Al-2Sn-4Zr-2Mo and Beta 21S. Standard material and foil/fiber/foil process techniques were used to evaluate the lot-to-lot and panel-to-panel properties of comparable material. The panels were then provided to gas turbine engine and airframe manufacturing vendors to conduct secondary processing. The areas of investigation included machining, bicasting, hole generation, etc.

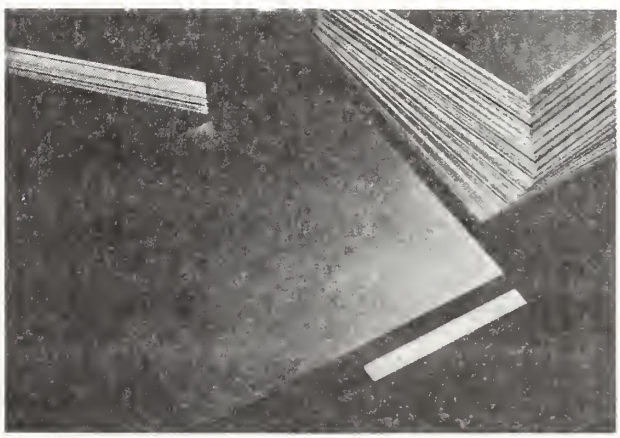
PROJECT BENEFITS

The ability to fabricate consecutive lots of panels, identical in most respects, allowed evaluation of existing process techniques and presented the opportunity to demonstrate the potential for cost reduction. The same paperwork, processing conditions, layup, and tool setup were used to fabricate all of the panels. This yielded an 82.8% improvement curve for direct, hands-on labor for the fabrication of SCS-6/Beta 21S panels.

Semi-production fabrication showed a greater than 50% reduction in cost compared to single panel fabrication.

APPLICATIONS

This type technology can be applied where high specific strength components are required. Heavy steel and superalloy parts may be replaced to yield lighter weight airframes and engines.



Continued on reverse side

PROJECT STATUS

The fabrication and accompanying documentation of the panels was completed. The vendor assessments will be completed later this summer.

TECHNICAL DOCUMENTATION

The technical report is being processed and will be available May, 1992. Written requests for the report may be sent to: WL/MT (Technology Transfer Center), Wright-Patterson AFB, OH 45433-6523.

GOVERNMENT SPONSOR

Wright Laboratory
WL/MTPM (Ms. Stacey Rickles)
Wright-Patterson AFB, OH 45433-6523
(513) 255-3612 DSN: 785-3612

COMPANY POINT-OF-CONTACT

Textron Specialty Materials
Attn: William Grant
2 Industrial Avenue
Lowell, MA 01851
(508) 454-5650

INDUSTRIAL TECHNOLOGY OMBUDSMAN

Wright Laboratory
WL/MTX (Robert Reifenberg)
Wright-Patterson AFB, OH 45433-6523
(513) 255-7362

APPROVED FOR PUBLIC RELEASE

The purpose of the **Technology Transfer Bulletin** is primarily to highlight successful or promising applications of industrial technologies with proven or probable worth to industry and the Air Force. It also provides a vehicle for airing initiatives within the Air Force Industrial Base Program. This document provides an awareness of these technologies and initiatives to foster interaction between industry and the Government to benefit the defense industrial base. All comments concerning this document should be addressed to WL/MTX (Industrial Technology Ombudsman) Wright-Patterson AFB, OH 45433-6523.

The **Technology Transfer Bulletin** does not imply any endorsement or commitment by the Government to procure given technology, process, or product.

FOREIGN DISSEMINATION

Details regarding many manufacturing technology programs (for example: MANTECH and IMIP) are subject to special export controls. Therefore, follow-up from any foreign source should be processed through embassy channels following normal procedures for request of technical information or technology transfer.

NAVY
Domestic Technology Transfer Fact Sheet

Mullite Whiskers and Mullite-Whisker Felt Produced

The Naval Surface Warfare Center (NAVSWC), Silver Spring, Maryland, has developed and patented processes for the economic manufacture of mullite whiskers and 80-percent porous mullite whisker felt to be used in preparation of advanced polymer-, metal-, and ceramic-matrix composites (Figures 1A, 1B). The rigid felt itself has the potential for applications such as high-temperature thermal insulation, catalyst supports, and filters. Mullite ($3Al_2O_32SiO_2$) has good retention of strength at high temperatures, a low thermal expansion coefficient, and a low dielectric constant and loss tangent. An important advantage of mullite whiskers compared with nonoxide whiskers, such as silicon carbide, is that they can be used in an oxidizing environment at high temperatures as well as in electronic ceramics.

The felt consists of randomly oriented stoichiometric mullite whiskers, which are mutually interwoven forming a rigid structure. A significnt aspect of the felt-preparation process is that there are no whiskers in the precursor mixture. The whiskers are formed in-situ during the firing step. Loose whiskers are not handled at any step of the process, thus health hazards associated with handling loose whiskers are eliminated. Another important feature is that the dimensional change between the green preform and the final fired shaped felt is low, about one-percent expansion. This enables the fabrication of near-net shape preforms for composites that will require minimum machining.

Figure 1B. Mullite-Whisker Felt

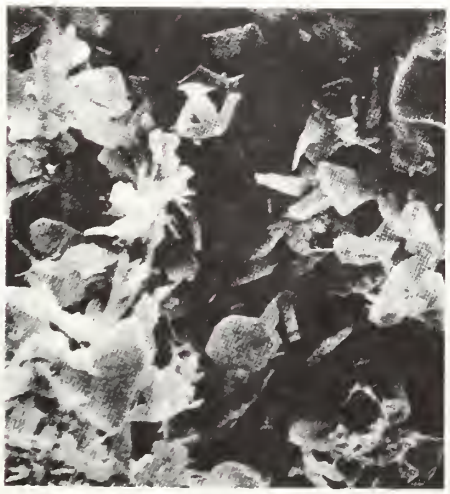


Figure 1A Mullite Whiskers

For Additional Information:

Backup material on this effort is available from:

Navy Domestic Technology Fact Sheet Reader Reply Service
Code E211
Naval Surface Weapons Center
Dahlgren, VA 22448-5000
(703) 663-8921

Refer to 161201/TN

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Licensing Opportunity

Polymeric Electrolyte Containing 12-Crown-4 Ether

Ionic conductivity and charge-transfer efficiency are enhanced.

Experiments show that the incorporation of 12-crown-4 ether into solid electrolytes based on polyethylene oxide can enhance their electrochemical properties. More specifically, 12-crown-4 ether may increase the Faradaic efficiency for Li^+ ions in low-power secondary Li cells and thus may enable the operation of these cells at lower temperatures with higher efficiencies.

The conductivity-enhancing effect of 12-crown-4 ether was investigated by measuring the conductivities of thin films of polyethylene oxide/CF_3SO_3Li (5:1 mole ratio of polyethylene oxide to CF_3SO_3Li) cast from solution without and with various concentrations of 12-crown-4 ether. The results of dc electrochemical measurements of ionic conductivity (see Figure 1) and of plating/stripping of Li show that the bulk ionic conductivity of the polymer incorporating 12-crown-4 ether exceeds that of the polymer. Similarly, measurements of the complex impedances at various frequencies (see Figure 2) show that the charge-transfer resistance is smaller for the samples incorporating 12-crown-4 ether.

This work was done by Ganesa Nagasubramanian and Salvador DiStefano of Caltech for **NASA's Jet Propulsion Laboratory**.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA's Resident Office-JPL. Refer to NPO-17922/TN.

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization Officer: Arif Husain
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4862
Patent Counsel: Thomas H. Jones
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-5179
Technology Utilization Mgr. for JPL: Dr. Norman L. Chalfin
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

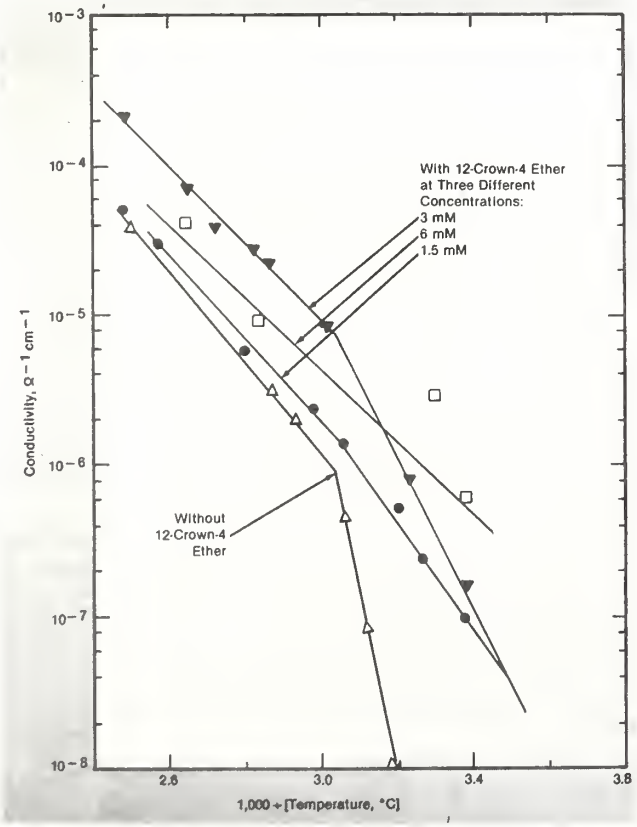


Figure 1. The **dc Ionic Conductivities** of films of (polyethylene oxide)$_5CF_3SO_3Li$ containing 12-crown-4 ether at various concentrations were measured over a range of temperatures.

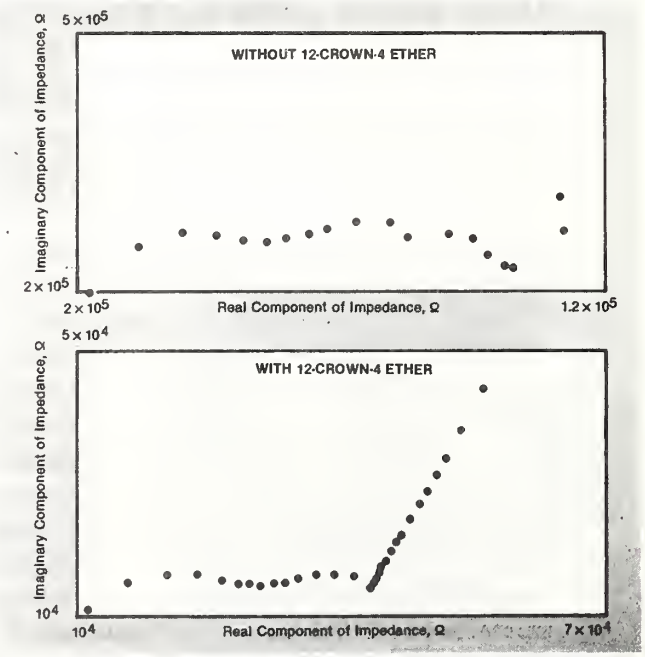


Figure 2. The **Complex Impedances** of two (polyethylene oxide)$_5CF_3SO_3Li$ films, one of which contained 12-crown-4 ether at a concentration of 12 m*M*, were measured at frequencies from 0.1 Hz to 100 kHz.

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Medicine & Biology

0521 From Cattle Toxin to Anti-Cancer Drug—Locoweed, poisonous to livestock, contains a component that destroys malignancies.

0522 Human Cell Repositories

0523 Containing Hair During Cutting in Zero Gravity—A device would enclose the head in a plastic bubble while a barber works.

Software

0524 Computer Graphics Simulation

Testing & Instrumentation

0525 White-Light, Dispersed-Fringe Interferometric Keratometer—A single 'snapshot' would suffice to map a cornea. (Licensing Opportunity)

Research Technology
Agricultural Research Service
U.S. Department of Agriculture

From Cattle Toxin to Anti-Cancer Drug

Locoweed, poisonous to livestock, contains a component that destroys malignancies.

Detective work that unmasked a plant toxin poisonous to beef cattle has helped medical science in its search for cancer-fighting weapons.

The toxin, swainsonine, can weaken and eventually kill not only cattle, but also horses, sheep, goats, and other animals that graze on the dozen or so rangeland plants commonly known as locoweeds, says ARS chemist Russell J. Molyneux at Albany, California.

But medical researchers, feeding the compound to laboratory mice, have discovered that swainsonine also stops growth of malignant tumors. Those scientists used tiny doses, unlikely to harm humans or animals.

Here's how this chemical from cattle-poisoning weeds in the American West ended up in cancer labs.

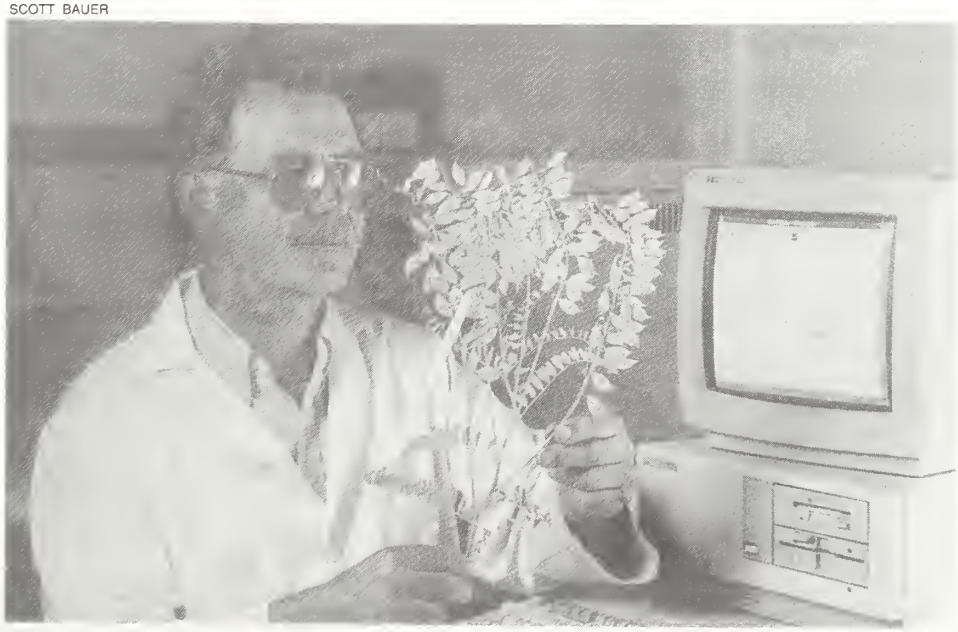
Molyneux and colleague Lynn F. James at the ARS Poisonous Plants Laboratory in Logan, Utah, pinpointed swainsonine as the culprit in locoweed poisonings about 10 years ago. Their finding came about a year after Australian scientists discovered and named the toxin.

An article in *Science* by Molyneux and James noted swainsonine's effect on animal cells, first described by the Australians. Swainsonine soon captured the interest of medical researchers.

Among them was Kenneth Olden, head of a research team at Howard University Cancer Center in Washington, D.C. He realized that swainsonine might offer a promising new approach to fighting cancer.

Teams like Olden's went on to discover that small doses of swainso-

SCOTT BAUER



Chemist Russell Molyneux examines a locoweed plant while working with the structure of locoweed toxin, swainsonine, on the computer. (K-4269-4)

nine will indeed stop the spread of malignant tumors in laboratory mice. Swainsonine probably does that by boosting the number and activity of macrophages, helpful cells that fight cancer and other diseases.

Cancer research with swainsonine is continuing in labs in the United States, Canada, and Japan.

Olden's team first used toxin purified and supplied by Molyneux, who extracted it from locoweeds collected by James' staff in Logan. As interest in it grew among medical researchers, companies began making the compound; today, scientists can choose from natural or synthetic swainsonine.

Whatever fame locoweed may earn as the source of a potential cancer-fighting drug, it already has a reputation in cattle country. Animals that eat it may spook easily, withdraw from their companions, or wander aimlessly.

The plants get their name from the word "loco," Spanish for crazy. Poisoned animals may weaken, lose weight, and—if pregnant—abort, or bear young with birth defects.

Every part of the plant—blooms, stems, and leaves—harbors the toxin. Plants remain poisonous even when dead and dry.

Ranchers could protect their animals by herding them away from locoweed-infested pastures and ranges when swainsonine levels climb. That's why Molyneux is tracking swings in the swainsonine content of American locoweeds such as the spotted species *(Astragalus lentiginosus)* or white locoweed *(Oxytropis sericea).*

Molyneux and the Logan team also want to find out how much swainsonine an animal normally converts into harmless compounds. "That's so we'll know—more precisely—how much locoweed animals can eat without danger," he says.

Swainsonine is an alkaloid, a class of chemicals that includes caffeine, cocaine, and strychnine. It may be habit-forming.

Poisoned animals, even if moved to safer pastures, will be more susceptible to swainsonine's effects if they ever again graze locoweed.

Russell J. Molyneux is with USDA-ARS Plant Protection Research, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710. Phone (510) 559-5812. ◆

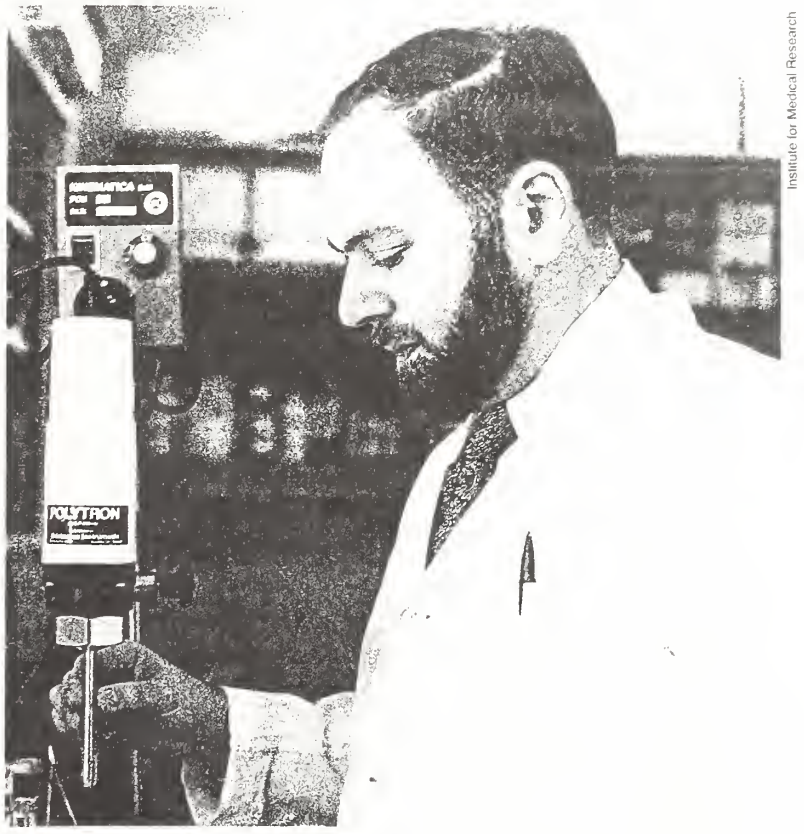
NIH
Research & Technology
Federal laboratory resource
U.S. Department of Health and Human Services Public Health Service National Institutes of Health

Human Cell Repositories

The Coriell Cell Repositories (CCR), part of the Coriell Institute for Medical Research in Camden, New Jersey, establish, characterize, store, and distribute to researchers cell lines and DNA samples from more than 7,000 cell cultures.

The CCR houses two National Institutes of Health cell repositories: the Human Genetic Mutant Cell Repository of the National Institute of General Medical Sciences (NIGMS) and the Aging Cell Repository of the National Institute on Aging (NIA). The CCR is also home to the National Cell Repository of the National Institute of Mental Health (NIMH). Taken together, these repositories constitute the world's largest collection of living human cells; the cell lines represent more than 400 genetic diseases, 800 chromosomal aberrations, and 100 age-related disorders, as well as cancer, diabetes, and other diseases. (For more information about a diabetes-related cell repository and database, see the *Research Resources Reporter*, October 1991.) Since the creation of the first collection in 1972, more than 60,000 cell lines from the repositories have been distributed internationally to scientists who are investigating the genetic components of these disorders, according to Dr. Richard Mulivor, principal investigator at all three repositories and director of the CCR.

The Human Genetic Mutant Cell (HGMC) Repository, established in 1972, has provided scientists with cell lines for the study of many genetic conditions, particularly in the area of gene mapping. This service saves investigators the considerable investment in time, money, and expertise required to locate appropriate tissue donors, obtain tissue samples, prepare cell cultures, characterize the cultures, certify their sterility, and freeze and store them. In the fall of 1990 the HGMC Repository expanded this service and began offering DNA samples from rodent-human hybrid cell lines as well as from human cell cultures.



Institute for Medical Research

Dr. Richard A. Mulivor, director of the Coriell Cell Repositories, prepares a homogenate of cells for enzyme activity analysis.

"What we can now offer scientists is the opportunity to purchase, at a nominal fee, well-characterized hybrid cultures or DNA samples. Carefully controlled materials of this type have never before been so widely available commercially," Dr. Mulivor says.

He describes the complexities of the process. "When we receive a hybrid cell culture sample from an outside source we expand it, then test it for sterility and growth so that clients know they will be getting cells that are not contaminated and will grow well. Then we do chromosome studies on the hybrids, which allow us to identify the intact human chromosomes present in the hybrid, whether pieces of human chromosomes have been translocated to rodent chromosomes, and whether there are human chromosome fragments present."

This is only the beginning, Dr. Mulivor notes. The cell cultures must be expanded to produce DNA at a later step, reverified cytogenetically, and analyzed with a variety of DNA probes for the human chromosomes present to exclude contamination or other changes of the cultures.

A researcher can arrange for a shipment of the material and begin his or her experiments almost immediately. "Before hybrids were available from our repository, an investigator typically would have had to take the time to locate a collaborator to provide the material," Dr. Mulivor explains.

The fee, which is set by NIA, NIGMS, or NIMH, depends upon the

exact amount and type of material requested but is not meant to recoup the costs of the process. The requesting investigators receive seed stock that should be expanded and used as a resource for their future research. "They should not come back to us every week for another flask of cells," Dr. Mulivor says.

The HGMC Repository has shipped nearly 2,000 50-microgram aliquots of DNA thus far. "When we started shipping DNA we really had no idea what the demand would be. The goal was to ship 200 aliquots per year, so we underestimated the demand by a factor of 10," he says.

The Aging Cell Repository, established in 1974, currently contains close to 1,500 cell lines from individuals with aging-related conditions and is expected to collect, characterize, and store up to 2,700 more over the next several years. The clinical symptoms of the disorders represented in this collection are different forms of accelerated aging, either at the level of an organ or organ system or at the level of the entire organism. Juvenile diabetes, Down syndrome, and Alzheimer's disease are thought to have accelerated aging as a component and are represented in the collection, as are atherosclerosis and parkinsonism, according to Dr. Mulivor.

The Aging Cell Repository also includes a large collection of skin fibroblast cultures from subjects participating in the NIA-sponsored Gerontologic Research Center Baltimore Longitudinal Study. These subjects are normal volunteers, 17 to 96 years old, who receive annual physical examinations, including blood and occasional tissue sampling, throughout their lives. The cell lines obtained from them can be used to compare a subject's cells against his or her clinical history at various times in the aging process. The mechanisms of aging can also be studied in comparisons between cells of subjects of different ages or between human fibroblasts and animal fibroblasts, which are also in the collection.

"We have developed animal and human differentiated cell cultures such as epithelial, endothelial, and smooth-muscle cell cultures and cultures of fibroblasts derived from organs other than skin, such as lung fibroblasts," Dr. Mulivor adds.

The NIMH National Cell Repository, the third repository at the CCR, was established in 1990 to create and store cell cultures derived from blood cells of volunteers who have Alzheimer's disease, manic depression, or schizophrenia, as well as from their relatives. The collection is expected to hold 6,000 such cell lines by 1993 and 7,500 by 1995.

An important distinction between this and the other CCR repositories is that it is not yet a public access repository. The material will be collected by 10 regional research centers across the United States, and after the cells have been cultured at the CCR they will be distributed only to those same research centers.

"Initially each institution will only get back its own material. Then in the first phase of opening up the repository, the fellow researchers at the 10 regional centers will have access to each other's material. We expect that at the end of 5 years the material in the repository probably will become available to qualified investigators," he says.

In addition to the materials provided by these repositories and smaller collections of other cell cultures, the Coriell Institute offers investigators several educational opportunities, including a visiting scholar program, internships, postdoctoral fellowships, and summer positions for undergraduate students.

For additional information on the Coriell Cell Repositories, contact:
Dr. Richard A. Mulivor
Coriell Institute for Medical Research
401 Haddon Avenue
Camden, NJ 08103
Telephone: (609) 757-9697
or (800) 752-3805
FAX: (609) 964-0254

NASA Tech Brief
National Aeronautics and
Space Administration

Containing Hair During Cutting in Zero Gravity

A device would enclose the head in a plastic bubble while a barber works.

A proposed device described in a brief report would collect loose hair during barbering and shaving in zero gravity to prevent hair clippings from contaminating the cabin of a spacecraft. The device, which would be folded for storage, would open into a clear, bubblelike plastic dome that surrounds the user's head, a tray that fits around the user's throat, and a fanlike ring that surrounds the back of the neck. The device would fit snugly but comfortably around the neck, preventing hair from escaping to the outside. The flow of air into a hose connected to a suction pump would remove hair from the bubble as it is cut. A filter at the end of the hose would collect the hair.

In space, where microgravity would allow haircuttings to float freely within the bubble until sucked out by the pump, the user would breathe through a mouthpiece and air tube connecting to the outside so as not to inhale cuttings. The user would keep eyes closed or wear small goggles during cutting.

The barber would insert hands into the bubble through snugly fitting holes. The barber could introduce the haircutting tools through the holes. Alternatively, the implements would be mounted on the tray, inside the bubble, in fixtures that hold them securely but allow quick and easy removal. In space, of course, both the device user and the barber would need foot and body restraints to hold themselves in position.

This work was done by Richard F. Haines of **Ames Research Center**. *"Microgravity Barbering/Shaving Facility." ARC-11668/TN*

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*
REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Computer Graphics Simulation

Patients with movement disabilities frequently undergo surgical reconstructions aimed at improving their limb function. Stroke patients, for example, often undergo tendon transfer surgeries. During this surgery a tendon is detached from one location and reattached to another, in order to improve the patient's ability to walk or grasp. Although surgical reconstructions sometimes improve function, these procedures can compromise the capacity of the muscles to generate force. Patients that cannot generate enough muscle force are left with weak or dysfunctional limbs.

Now, using software developed at the Rehabilitation R&D Center, VA Medical Center, researchers can simulate musculoskeletal reconstructions and evaluate their biomechanical effects. Surgery simulations can give insight into the potential consequences of a surgical technique before performing an actual operation.

A computer-graphics workstation (Silicon Graphics Iris 4D/25) displays a realistic model of the human skeleton and the muscles and tendons that attach to it. This computer model can be altered according to a particular surgical technique. The results of the alterations are then displayed. For instance, a tendon transfer can be simulated by graphically moving a tendon attachment from one location on the limb to another. The computer model then determines how this simulated surgery affects the muscle forces and other biomechanical variables. These effects then appear in graphical form on the display screen.

Researchers have used surgery simulation to analyze tendon transfers, hip replacements, and other musculoskeletal reconstructions. As an additional benefit, the use of computer graphics has fostered interaction among engineers, physicians, and other health professionals.

The surgery simulation and modeling software is now being tested at four universities in a wide range of applications. At the University of Texas, Austin, Department of Physical Education it is being used to analyze human jumping. In the Department of Bioengineering at Arizona State University, it is being used to simulate normal and pathologic walking. At University of California, Davis, it is being used in the Mechanical Engineering Department to analyze shoulder movement. And, in the Department of Integrative Biology at University of California, Berkeley, it is being used to develop models of other animals.

The authors of the software and the technology transfer staff are now exploring the possibility of distributing this software through commercial channels.

FOR ADDITIONAL INFORMATION: For technical information about this project, contact Scott Delp, Peter Loan or Eric Topp, (415) 493-5000, ext. 4474. For information about patent rights and licensing, call Al Sacks at (415) 493-5000, ext. 4475.

NASA Tech Brief
National Aeronautics and Space Administration
NASA's Jet Propulsion Laboratory, Pasadena, California

Licensing Opportunity

White-Light, Dispersed-Fringe Interferometric Keratometer

A single "snapshot" would suffice to map a cornea.

A proposed keratometer (an optical instrument that measures the shape of the cornea) would be based on a novel scheme that involves the spectral dispersal of white-light interference fringes. While the instrument is intended primarily for use in medical assessments of human corneas, it could also be used to measure the shapes of animal corneas, lenses, and other aspherical or spherical reflective or partly reflective surfaces. A primary advantage of the instrument is that it would operate in a "snapshot" mode: no scanning would be necessary, and it would not be necessary to immobilize the patient's eye. The instrument would be insensitive to vibration, would involve no phase shifting, and would have variable sensitivity.

The bulk of the instrument would be a Twyman–Green interferometer with a source of white light (see Figure 1). The optical train would be achromatized, principally by use of reflective (as opposed to refractive) optics. By use of an area-to-line manifold of optical fibers and a prism or other disperser, the spectrum at each of a number of points in the polychromatic interference image would be spread out on a two-dimensional array of detectors, with wavelength along one axis and position along the other axis (see Figure 2). It has been shown that the autocorrelation function of the spectrum at each such image point should be characteristic of a given interferometric optical-path difference that corresponds to a given height, at that point, of the cornea or other surface under test. Thus, one could generate topographical data on the surface in a single exposure (e.g., a single video frame), without vibration-sensitive scanning or phase shifting.

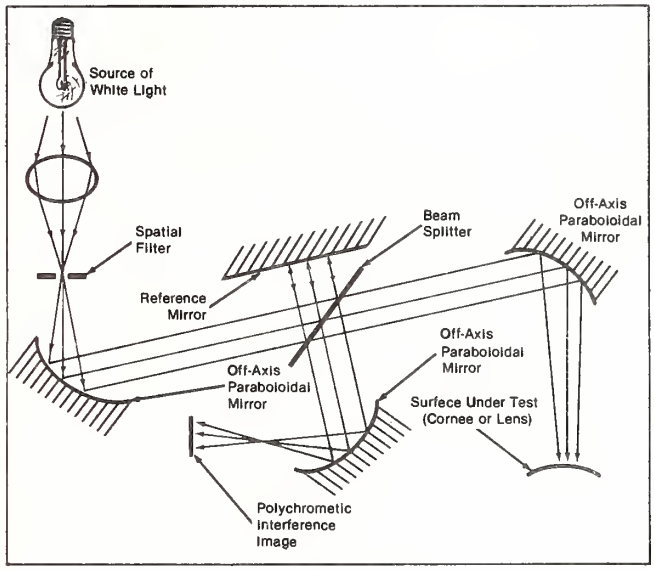
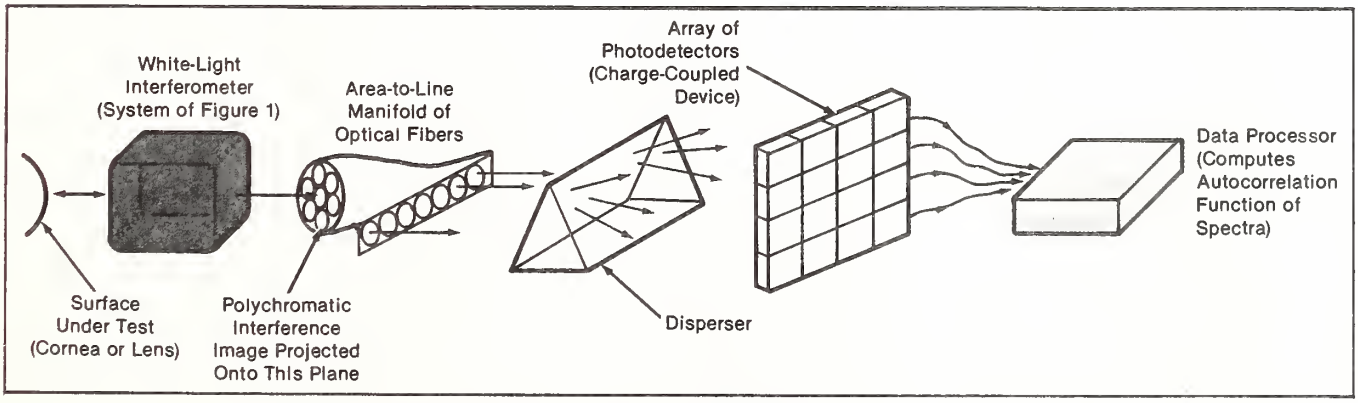


Figure 1. A **Twyman-Green Interferometer** illuminated by white light would generate a polychromatic interference image of the surface under test.

Figure 2. **Spectra at a Number of Sampling Points** in the polychromatic image would be measured, and the autocorrelation function of the spectrum of each point would indicate the height of the surface under test at that point.


White-Light Interferometer (System of Figure 1)
Area-to-Line Manifold of Optical Fibers
Array of Photodetectors (Charge-Coupled Device)
Data Processor (Computes Autocorrelation Function of Spectra)
Surface Under Test (Cornea or Lens)
Polychromatic Interference Image Projected Onto This Plane
Disperser

To obtain the benefit of this "snapshot" approach, it would be necessary to pay a penalty in the form of sparse sampling of the surface under test. This is because the points in the two-dimensional test pupil would not be mapped onto a two-dimensional detector array, but only onto a number of points equal to the number of detectors along one axis of the array (the other axis being reserved for dispersion of the spectrum). One could trade-off the number of sampling points, resolution or sensitivity (uncertainty in the optical-path difference), and dynamic range (maximum optical-path difference) against each other. For example, a preliminary analysis shows that the topography of a cornea could be measured to a resolution of 20 μm on an array of 74×74 sampling points, using a 256×256-element charge-coupled device as the detector array.

This work was done by Eric B. Hochberg and Edmund C. Baroth of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 87 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
1201 East California Boulevard
Pasadena, CA 91125

Refer to NPO-17955/TN.

Jet Propulsion Lab.
NASA Resident Office
Technology Utilization Officer: Arif Husain
Mail Stop 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-4862
Patent Counsel: Thomas H. Jones
Mail Code 180-801
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-5179
Technology Utilization Mgr. for JPL: Dr. Norman L. Chalfin
Mail Stop 156-211
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*

REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

Physical Sciences

0526 More Sensitive Analysis: X-Ray Microprobe/Microscope

0527 Measuring Magnetic Fields: The Mole

Other Items of Interest

0488 Fiber-Optic Probe for Laser Velocimetry—The size and weight of optics would be reduced considerably. (Licensing Opportunity)

0505 New Technique for Assessing Groundwater Quality

0520 Polymeric Electrolyte Containing 12-Crown-4 Ether—Ionic conductivity and charge-transfer efficiency are enhanced. (Licensing Opportunity)

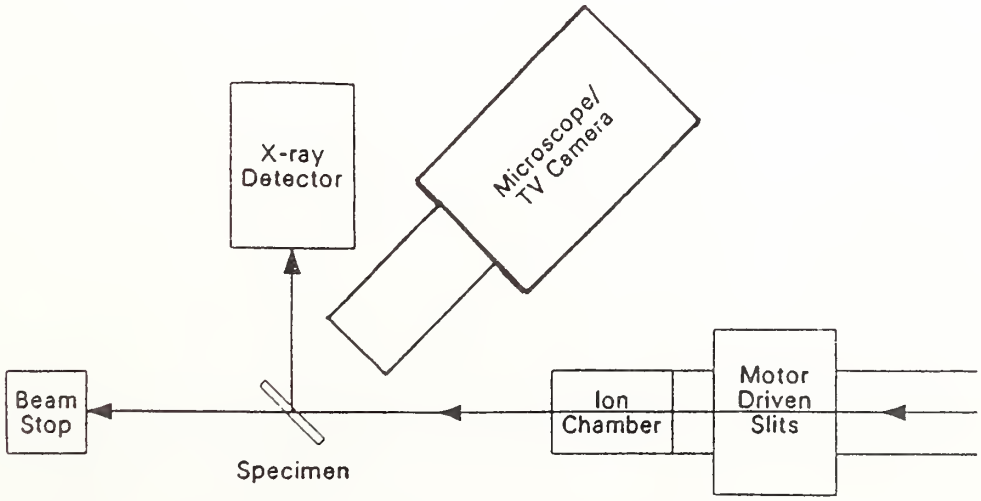
Brookhaven National Laboratory

More Sensitive Analysis: X-Ray Microprobe/Microscope

The x-ray microprobe/microscope (a 1988 R&D 100 Award winner) is a unique analytical instrument for determining the specific contents of materials. Developed by researchers at Brookhaven National Laboratory and the University of Chicago, the instrument can measure the concentration and spatial distribution of trace amounts of elements, from silicon to uranium in the periodic table, with excellent spatial resolution and sensitivity.

The device uses simple components to collimate x-rays to a small size so that the well-known technique of x-ray fluorescence can be used to identify each element. In a marked improvement of this basic technique, however, the specimen is excited with an intense beam of continuous energy x-rays produced by Brookhaven's National Synchrotron Light Source. The Light Source produces more x-rays per unit area per second than any other x-ray source.

An important application for the collimated x-ray microprobe/microscope, which is abbreviated as CXRM, is for geological and metallurgical studies, where the instrument can be used to determine and map elemental distributions in heterogeneous geological samples. Another application is in the biological sciences, for which elemental concentrations can be determined in tissue sections and even living cells.



The x-ray microprobe/microscope collimates x-rays to a small size so that x-ray fluorescense can be used to identify elements.

Literature: (1) K.W. Jones et al., X-Ray Fluorescence with Synchrotron Radiation, Ultramicroscopy 24:313-328, North-Holland, Amsterdam, 1988. (2) K.W. Jones et al., X-Ray Microscopy Using Collimated and Focussed Synchrotron Radiation, Advances in X-Ray Analysis 31:59-68, Plenum Press, New York, 1988.

Patent Status: No patent, none pending.

Applications/Spinoffs: Geological, metallurgical studies; biological sciences.

FOR ADDITIONAL INFORMATION: Margaret C. Bogosian, Office of Technology Transfer, Brookhaven National Laboratory, Building 902-C, Upton, New York, 11973; Phone: Commercial (516) 282-7338, FTS (516) 666-7338.
Refer to BNL/AA-44 R.

Brookhaven National Laboratory

Measuring Magnetic Fields: The Mole

Researchers at Brookhaven National Laboratory have developed an instrument that can analyze the magnetic field in magnets built for particle accelerators. Called a Mole because it burrows through the center of a magnet, the device is being used to make measurements of prototype magnets for the nationally proposed Superconducting Super collider (SSC) and for the Relativistic Heavy Ion Collider, which is proposed to be built at Brookhaven.

In such machines, sometimes called atom smashers, magnets keep particles on track as they whirl around a circular accelerator at close to the speed of light. The SSC, for example, which would be the world's largest and highest energy accelerator for high energy physics research, would be 52 miles in circumference and would require about 10,000 superconducting magnets. The bulk of the magnets would be dipole magnets, each one 60 feet long, with a center aperture of about 1.25 inches in diameter.

The field of each magnet must be analyzed at room temperature, and a statistical sampling of magnets must be measured at their operating temperature of 4.5 Kelvin (about -450 degrees F) and magnetic field of 6.6 teslas. A series of Moles optimized for industrial use would be the only practical way to perform the magnetic field quality control required for SSC production magnets.

Brookhaven's Mole is a self-contained apparatus made of miniaturized pneumatic motors and rotary components, an ultra-precise gravity sensor, a miniature encoder assembly and a coil assembly about three feet long. Because the device must operate in a high magnetic field, its parts are made of special nonmagnetic metals and composite plastics. It also boasts the first use of precision ceramic ball bearings in the motors an coil assembly.

The Mole is pulled through a magnet, stopping approximately every three feet to measure the characteristics of the field. Future versions of the device may be self-propelled so that it can go by itself through many consecutive magnets of an existing accelerator.

The mole is the winner of a 1988 R&D 100 Award.

Literature: G. Ganetis et al., Field Measuring Probe for SSC Magnets, BNL Report No. 39607, March 1987.

Patent status: No patent, none pending.

Applications/Spinoffs: Analysis of magnets for particle accelerators.

FOR ADDITIONAL INFORMATION: Margaret C. Bogosian, Office of Technology Transfer, Brookhaven National Laboratory, Building 902-C, Upton, New York, 11973; Phone: Commercial (516) 282-7338.
Refer to BNL/AA-45 R.

Transportation & Components

0528 Automatic Pilot for Flight-Test Maneuvers—Experimental maneuvers can be repeated accurately.

NASA Tech Brief
National Aeronautics and Space Administration
Ames Research Center, Moffett Field, California

Automatic Pilot for Flight-Test Maneuvers

Experimental maneuvers can be repeated accurately.

An autopilot controls a highly maneuverable, remotely piloted aircraft during flight tests. It puts the aircraft through such maneuvers as level acceleration and deceleration, pushover/pullup maneuvers, excess-thrust windup turns, thrust-limited windup turns, level turns, and the rocking-horse maneuver.

The autopilot usually meets and often exceeds the demanding maneuver tolerances: mach number accurate within ± 0.01, altitude within ± 150 m, angle of attack within $\pm 0.5°$, and normal acceleration within $\pm 0.5 \times$ normal gravitation. It increases the quality of maneuvers significantly beyond that attainable through remote manual control by a pilot on the ground. It also increases the quality of maneuvers because it performs maneuvers faster than a pilot could and because it does not have to repeat poorly executed maneuvers.

The aircraft transmits sensor data to the ground (see figure) for use in the cockpit displays on the ground and in the primary-control-system computer. In manual operation, the computer combines the ground pilot's commands with the sensor data. In automatic operation, however, commands generated by the autopilot replace those from the pilot.

The autopilot generates the commands by comparing processed sensor data with those that correspond to the flight-test maneuver selected by the pilot. The autopilot continuously updates the trajectory according to the sensor data it receives. The primary-control-system computer then uses the control law to generate a servoactuator command for the control surfaces and throttle of the aircraft. It sends the servo commands to an uplink encoder for transmission to the aircraft.

The **Autopilot Replaces the Pilot** during automatic maneuvers. The pilot, based on the ground, flies the aircraft to the required altitude, then turns control over to the autopilot.

The autopilot selects various combinations of flight modes according to the maneuver being executed:

- The altitude-hold mode maintains altitude during straight and level flight.
- The angle-of-attack mode provides control of the longitudinal axis during windup turns and pushover/pullup maneuvers.
- The normal-acceleration mode is used in windup turns and the rocking-horse maneuver.
- The wings-level mode controls the lateral axis in both straight and level flight and pushover/pullup maneuvers.
- The turn-control mode controls the lateral axis during any of the turning maneuvers.
- The throttle-control mode is used in all maneuvers except the pushover/pullup with fixed throttle.

The control laws were established by linear analysis and classical design techniques and were expanded by including nonlinear elements. Additional maneuvers can be easily constructed from the basic laws.

This work was done by Eugene L. Duke, Frank P. Jones, and Ralph B. Roncoli of **Ames Research Center**. *Further information may be found in NASA TP-2618 [N88-21153], "Development and Flight Test of an Experimental Maneuver Autopilot for a Highly Maneuverable Aircraft."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

ARC-12102 /TN

FOR ADDITIONAL INFORMATION: *Contact: Director, Technology Transfer Division, P.O. Box 8757, BWI Airport, MD 21240; (301) 621-0100 Ext. 241*

REFER TO THE NUMBER LISTED AT THE END OF THIS ARTICLE

*U.S. Government Printing Office: 1992 — 311-885/60008

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
Springfield, VA 22161

NTIS ORDER FORM

Use this form ONLY to order reports designated as available from NTIS.

TELEPHONE ORDERS (703) 487-4650 FAX (703) 321-8547 TELEX 89-9405

Rush Service
1-800-553-NTIS

For Subscription Questions
(703) 487-4630

For Tracing an Order
(703) 487-4660

For Editorial Questions
(703) 487-4805

If your address label on this Tech Notes is NOT correct, call the NTIS Subscriptions Department on (703) 487-4630.

1 ADDRESS INFORMATION

Last Name .....

Title .....

Company/Organization .....

Address .....

.....

City/State/ZIP .....

Telephone Number .....

2 METHOD OF PAYMENT

☐ Charge my NTIS Deposit Account .... – .....

☐ Check/Money order enclosed payable to NTIS for $ .....

☐ Purchase order **ADD $7.50 per order** (U.S., Canada, and Mexico only)

Purchase order number .....

Charge my ☐ American Express ☐ VISA ☐ MasterCard

Account Number. ..... Exp. .....

Signature .....
(Required to validate order)

3 ORDER SELECTION (Use only for reports stated as available from NTIS)

NTIS Order Number	*Price**	*Quantity*	*Total Price*
..... /NAC	.....	.....	.....
..... /NAC	.....	.....	.....
..... /NAC	.....	.....	.....
..... /NAC	.....	.....	.....
..... /NAC	.....	.....	.....
		Handling fee	$3.00
		Total	.....

NTIS PRICE SCHEDULE *

This schedule converts into actual prices the price codes cited in those Tech Notes having a report available from NTIS.

Price Code	*Price*
A01	$9.00
A02	12.50
A03	17.00
A04 through A05	19.00
A06 through A09	26.00
A10 through A13	35.00
A14 through A17	43.00
A18 through A21	50.00
A22 through A25	59.00
A99	Contact NTIS for price

These prices are for customers in U.S., Canada, and Mexico. Other addresses should write for the price listing, number PR-360-4.

Prices effective October 1, 1991

10/91

- Agriculture & Food
- Computers
- Electrotechnology
- Energy
- Engineering
- Environmental Science & Technology
- Manufacturing, Machinery, & Tools
- Materials
- Medicine & Biology
- Natural Resources Technology & Engineering
- Physical Sciences
- Transportation & Components

Route To:

PENN STATE UNIVERSITY LIBRARIES
A000072009864

DEPARTMENT OF COMMERCE
nal Technical Information Service
field, Va. 22161

IAL BUSINESS
y for Private Use, $300

AN EQUAL OPPORTUNITY EMPLOYER

BULK RATE
POSTAGE & FEES PAID
NTIS
Permit No. G-292